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SNAKES ALIVE

AND HOW THEY LIVE

Snakes Alive

AND HOW THEY LIVE

BY CLIFFORD H. POPE

ILLUSTRATED WITH PHOTOGRAPHS
AND INCLUDING AN ILLUSTRATED KEY
FOR THE IDENTIFICATION OF THE
SNAKES OF THE UNITED STATES

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Papers of the Michigan Academy of Science, Arts and Letters for Fig. 12, Pl. 56, Vol. 17, reproduced facing page 73.

Occasional Papers of the Museum of Zoology, University of Michigan, for Fig. 2 of Pl. 3, No. 287, and Figs. 1 and 3, of Pl. 2, No. 329, reproduced facing pages 72 and 105.

Publications of the University of California at Los Angeles in Biological Sciences for the illustration on page 60, Vol. 1, No. 3, reproduced facing page 105.

—C. H. P.

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SNAKES ALIVE

AND HOW THEY LIVE

1

A LOVER OF SNAKES

So few people like snakes that anyone who not only likes them but spends much of his time studying them is sure to be asked: "How did you come to like snakes and when did you first become interested in them?" Of all questions, I have had to answer the second of these most frequently; the first I cannot answer. My father says that when shown early one day a hole under our house and told that a snake had disappeared down it I spent the rest of the morning waiting for it to come out again. I was about five years old at the time and lived in the town of Washington, Georgia. When I was six we moved to Mt. Airy, a still smaller town in the northeastern part of the same state. My father had secured a fifty-acre farm with woods, peach orchards, fields, pasture, and garden. A stream flowed right across our land and along this stream I developed a love of snakes.

My earliest recollection of snakes at Mt. Airy takes me back to a walk to this stream with my mother. I killed a common garter snake, opened its mouth with two sticks, and said: "That's where its poison is." My mother's only reply was, "I'm sure it is harmless." Of course, she was right, but neither one of us actually knew anything about snakes, so we were glad to close the argument. My mother died soon afterward and I remember no other incident with snakes that involved her. The fact that I cannot recall that she ever said anything against snakes has always impressed me. She was sorry that I had killed the garter snake and was sure of its harmlessness, although she could not demonstrate her belief.

After my mother's death there was no one at Mt. Airy to encourage my interest in snakes. In fact, everyone discouraged or ridiculed or tried to frighten me. There was, however, one bright spot on the horizon; my mother's sister who lived in Savannah had given me a copy of Ditmars's *The Reptile Book*, and I was rapidly absorbing its contents. In spite of this I always had a sneaking fear that Ditmars *might* be wrong or that I might make a mistake. This fear was strongest after one of my little snakes had nipped me. Then I trembled lest the bitten place really throb and swell and everyone say: "I told you so." My imagination would go still further and I could see myself deathly sick with the deaf Mt. Airy doctor shaking his head and all my friends telling how they had warned me over and over again. These fears always wore off rapidly and I would find myself on the way back to the stream to search for more snakes.

I was ever alone with my pets for few boys lived near us and no one of them shared my interest. Common water snakes were easily found on our place, so it was with these that I played chiefly at first. My initial bit of real success happened one afternoon. I had a small specimen in a wire-fronted box of my own construction. Rocks, sticks, and a pan of water were in the box to make the snake feel at home, and a lone tadpole hid among the rocks in the pan. While I lay on the ground in front of the box the snake crawled into the water. This pleased me greatly, for was it not a water snake? My gaze followed its movements. The tadpole remained motionless as the snake's head slowly approached. I was all agog; was the snake actually interested in the tadpole? No snake had ever eaten for me up to this time. My excitement increased far more rapidly than the distance between snake and pollywog decreased. Didn't the tadpole realize that an enemy was approaching? Although on the point of being touched by the reptile's snout the tadpole did not move. A mouth deliberately opened and closed; a few movements of the jaws and the tadpole had vanished. Apparently far more emotion had been aroused in me than in the victim. I rushed off to find somebody to tell. I soon found my brother and sister busy with a game and, suppressing my excitement as much as possible, I told them what had happened. They thought the incident worth hearing about, but neither wanted to see the snake and so I returned greatly disappointed. Nobody else in my world really cared about snakes—I would have to love them all alone!

One morning at six o'clock my father called: "Clifford, get up, there's a snake down here for you." Excitement ran through me as always at that word and I dressed with lightning speed. The sight that met my eyes thrilled and warmed and chilled me all at once, for there in a box lay a shining ball of black and gold—a beautiful common king snake rolled up the way king snakes sometimes do when frightened. I couldn't take my eyes away from it, and eating breakfast was a trial. Life was wonderful with a brand-new kind of snake in my possession. There was a box to be made for it, food to be secured, its life history to be read about in Ditmars, and, best of all, there was the creature itself to be carried about in my pocket from daylight to dark. In fact I was so delighted with the snake that it was some hours before I stopped to learn how it had been caught. Our Negro cook, on her way to the cellar to get some stovewood, had seen a snake halfway under the cellar door. She had seized its tail, slowly worked its body out, and got it into the box without hurting it or being bitten herself. Thus I had found a new and true friend! To this day I have seldom seen such a display of courage, for our cook was afraid of snakes, daring to catch this one only because she knew how much I would like to have it.

At the age of eleven I went to Tome School, Port Deposit, Maryland. My interest in snakes was perfectly fixed by then, and there I found boys who also liked snakes. The snake craze that developed finally required the most severe disciplinary measures to curb. It so happened that a railroad watchman only two or three miles from Tome caught snakes as a pastime and usually kept some at his watch-box. It was from him that we drew our supply until our dormitory had become a good place in which to observe and even hunt snakes. If the aged mother of the director had not lived in our dormitory, severe rules might not have been thought necessary. Anyway, the director was afraid that the sight of a snake might seriously frighten so old a person and we were told that possession of one in the dormitory meant instant dismissal. This merely forced us to keep our boxes out of doors and our snakes out of sight. No one ever knew how many got loose in that dormitory, but I recall that one visiting girl fainted at a school dance when a snake dropped upon her from some overhead decorations.

In the fall of 1915, at the age of sixteen, I went to Marienfeld Plantation, Dr. C. Hanford Henderson's outdoor school near Pinehurst, North

Carolina. There for the first time in my life my interest in snakes was unrestrained. In fact, during the spring I fear that I spent more time hunting and playing with snakes than studying. Davis Merwin and I made a cement pit which we bordered on three sides with boards and on the fourth with a large box. The resulting pen measured about six feet on a side and was securely covered with wire. Into it we put any and every snake that we could find and no one objected or made special rules to disturb us. Dr. Henderson himself often came to see our catch. He looked at the specimens with interest, but steadfastly refused to hold them; we were always amused at this and asked why he was afraid. He denied being afraid but we were never fully convinced. We had among other kinds common king snakes, blacksnakes, common water snakes, coachwhips, and a fine pine snake. One afternoon we found a water moccasin which we caught with some misgivings and brought back. It did not take us long to decide to kill and skin it. At the end of the year I took the whole lot down to a wild valley and watched them crawl deliberately away to freedom.

The same aunt who had given me *The Reptile Book* had decided to do what she could to enable me to become a naturalist. She had seen Dr. Ditmars and persuaded him to permit me to work in his reptile house in the Bronx Zoological Park after leaving Marienfeld. The very thought of doing this thrilled me beyond measure, and I wasted no time in reaching New York and renting a room in the Bronx. I had never before known anyone who talked seriously about reptiles and actually received money for working with them as the keepers did. Keepers Toomey, Palmer, and Deckert did everything to encourage my interest, and the days flew by. This summer at the Bronx was the turning point of my life, for not till then did I learn that an interest in reptiles could be pursued seriously.

This interest in snakes never waned during the years I spent in college, but I did not acquire very much new information about them there. Many of my friends had advised me to learn about other things as well, and doubtless this good advice had its effect. I spent two summers at William Beebe's Tropical Research Station, Kartabo, British Guiana, but as soon as Dr. Beebe and Alfred Emerson learned that I was expecting to spend my time on reptiles and amphibians they gave me fish work to do! This was also by way of broadening my interests. It seemed to me even then that my love of snakes was destined to be squelched in one way or another.

Few sounds are more entrancing to the average youth of twenty-one than the word "expedition," and I was average enough to be held by its spell. In fact, I had just turned twenty-one and barely graduated from the University of Virginia when I left the United States to join Roy Chapman Andrews's Third Asiatic Expedition with headquarters in Peiping, China. I had joined as a zoological assistant to Dr. Andrews, but soon after my arrival he decided to send me out with my own party of trained Chinese skinners and other helpers. Although I collected mammals, fishes, and amphibians as well as reptiles, quite naturally I paid special attention to the latter, by no means neglecting the snakes.

Learning to speak Chinese proved to be a great pleasure as well as a necessity, and from the time of my arrival I found the Chinese such excellent company that the longer I stayed the more I liked the country and its people. In fact, the plan in sending me into the field as head of a party of locally trained workers was to initiate a complete program of exploration of all China; shortage of funds and disturbed conditions finally limited me to work in seven provinces over a period of four years.

During these four years I lived and worked under the most varied conditions: on houseboats, in temples or ancestral halls, in mission compounds or Chinese houses, or even in American tents. No matter where we were, it was always the same—animals, animals, animals; first netted, trapped, shot, bought or caught in any way possible and then preserved. Although, among many other large mammals, we hunted tigers (but shot none!) and secured leopards that had been killed by native poisoned arrows, wary mountain goats snared by ingenious Chinese devices, and even bears, we collected for the most part small creatures: fishes, frogs, turtles, lizards, snakes, and tiny furred animals.

While in the field I was always looking for local talent, and of all the clever helpers that I found, Ming Fa takes the prize, so I am going to tell you about him.

Although Ming Fa was only ten or eleven years old, he had no father or mother but lived with Yu Fa, his uncle. Their house was hidden away in remote mountain forests of southeastern China. Houses of relatives were strung along the same narrow mountain trail but not within sight. This string of houses was known as Kuatun and had not been visited by a white man other than Catholic missionaries for some twenty-five years when I arrived there in 1925.

It did not take us long to get acquainted, Ming Fa and I. He had a winning smile and a passion for catching anything that walked, swam, or flew; I had been sent by the American Museum of Natural History in New York for the sole purpose of collecting rare Chinese animals. Was it any wonder that we became friends immediately? Yu Fa was anxious for his nephew to sell animals to me; he had no ideas about snakes being bad things for boys to play with. On the contrary he took a keen interest in the snake catching of Ming Fa—and the pennies received from me in payment. I never knew just what became of this money but I have reason to suspect that Yu Fa got most of it. To Ming Fa the whole business was a game played between him and me. He appeared at my headquarters regularly every other day loaded with containers: cleverly cut bamboo joints, bottles, boxes made of big leaves and tied with grass, small home-made baskets, or even pieces of cloth. Each of these held its frog, lizard, snake, or small furred animal. Sometimes he brought so many containers that they made him look more like a moving rack than a boy. On his way he would carefully work out in just what order his specimens should be handed to me to make them seem most valuable.

It was a thrilling business opening these containers; one never knew what was going to happen. A poisonous snake might poke its head out or a rare frog take a flying leap through the glassless window and leave Ming Fa in a fit of despair. He always stood by explaining how rare this lizard was or how far he had gone to find that snake, and Ming Fa's imagination was not sluggish. Arguing, persuading, coaxing, and even threatening he would make the most out of every chance. Although he often left in a state of sham despair he never failed to return two days later fully bedangled with another lot of containers and wreathed in brand-new smiles. He proved himself so good in getting big prices that his friends frequently gave him their specimens to sell along with his own. Ming Fa's smiles were hard to resist, and he knew it. He would sometimes come up behind me while I worked at a table, put his arm over my shoulders, and smile down at me before saying anything. Then I knew that he had something for which he hoped to get an especially big price.

I have written a lot about Ming Fa not only because he was the best young collector that I found during my four years in China but because he illustrates the chief method that I used in securing specimens there. Of course I bought from adults as well as children but the latter were often the more eager helpers. This buying of animals was extremely worth while because it left me much free time to be out studying whatever I could find with my own hands and eyes. Many things that I wanted to learn about the animals of China could be discovered only by direct observation of the creatures themselves before they had been caught. For example, about seventy kinds of snakes live in Fukien Province, so while there I tried to find out just what type of country each frequents. To do this it was necessary to observe as many specimens as possible of each kind. That meant hundreds of hours of tramping through all types of country both by day and by night.

In Futsing Hsien three species of water snakes were brought in to us. Now these snakes look so much alike that they had been confused by specialists of European and American museums who had seen the few preserved specimens previously taken out of China. It was anything but clear why such similar kinds had been found in the same region, for naturalists know that very closely related animals do not usually inhabit the same places. It was but necessary for me to find these snakes wild to determine that one kind lives only in clear, cool, shaded mountain cascades; another in quiet water either of flooded rice fields or sluggish streams; the third in rapidly moving but not cascading streams of hilly open country.

Let us suppose that the snakes of the United States were known solely from preserved specimens in European museums and you had been sent to New Jersey to find out something about American snakes. You might pitch a tent in about the middle of the state somewhere east of Trenton. The New Jersey people would then sell specimens to you, but unless you went out to find snakes yourself you would never certainly learn that pine, corn, and common king snakes live only in the pine barren region to the south of your camp, common water snakes everywhere both to the north and south, timber rattlesnakes either in the wilder mountains of the north or the actual pine wastes in the south, and so on. Unless you worked very hard you certainly would not get a specimen of the little gray snake that has been found in New Jersey only a few times and always in the Watchung Mountains near Plainfield.

The fall of 1926 found me back at the American Museum with several thousand reptiles and amphibians waiting to be reported on. In other words I had passed the expeditionary and was ready to begin the studying stage. When specimens have been collected in a distant country and safely transported to a museum the task has just begun. It was first necessary to catalogue every one of the thousands now temporarily stored in glass jars and large crocks. Each one must have a number, and opposite this number all the information about it recorded in a large book or catalogue. After that every specimen is taken out and examined; its dimensions, sex, scale counts, and so forth tabulated. It would obviously be a waste of time and effort to publish all this information without first finding out how much of it is new or at least of special interest. In short, each animal is like a puzzle waiting to have its solution finished. It is often anything but easy to see just how far toward the end other workers have already advanced. In my case I had to go over about fifteen hundred published articles and books varying in length from one to many hundred pages. The majority of these works were in German and English, a good many in French, Russian, and Japanese, and a very few in still other languages. Anyone working in science should be able to read three of the major languages of the earth. German is especially important.

From almost the beginning of his work in Asia, Roy Chapman Andrews had planned to publish a series of volumes on the natural history of that continent. This series would of course include a book on reptiles and amphibians. The task of writing this volume had logically come into my hands. The more I studied my Chinese collections and compared specimens to published descriptions, the more I realized that I should visit the larger European museums to compare the Chinese reptiles and amphibians in their collections with those I had found. I estimated that six months should be allowed to complete this comparison. Everything was arranged, and in June 1932 I sailed for Europe with my family and returned the following November. The next two and a half years were spent finishing the volume. The information that I had brought together turned out to be too extensive to go into one book, so I compromised by leaving the frogs and salamanders out entirely. The result is a 604-page work, about four-fifths of which is devoted to snakes alone. It is called *The Reptiles of China* and was published in May 1935.

2

USEFULNESS

When Olympic winners return from Europe they are welcomed and cheered by great crowds. Animal as well as human champions are often given big receptions. In contrast to this the champion destroyers of harmful rodents among the snakes of the United States, the bull snakes, do not even enjoy protection but are nearly always attacked and killed at sight.

Let us see just what one of these reptiles may be worth to a farmer. Hisaw and Gloyd fed a lot of bull snakes and kept accurate track of the amount of food that they ate. A typical snake weighed 2.5 pounds and consumed in six months 6.7 pounds of food. Now this would be about the weight of twelve pocket gophers or the number ordinarily found on an acre and a half of alfalfa. The snake would scarcely be active for more than six months in a year, so we can conclude that a bull snake for every acre and a half might solve the pocket gopher problem. Since this problem is estimated to cost the farmer $3.75 per year for every acre and a half, it is obvious that bull snakes should be valued highly instead of slaughtered ruthlessly. Every time a bull snake is butchered a farmer has lost several dollars. Killing them is not unlike tearing up five-dollar bills because they frighten you or seem disgusting. The snake is in truth cleaner and more beautiful than the money.

Bull snakes are able to eat a surprising number of field mice at one time. Pack tells of one killed by some boys in Utah that held 35 of these rodents both young and old. Such facts as these do not keep many persons from killing useful snakes. There is the case of the farmer who, after pitchforking a large specimen, remarked: "I knew I'd find a snake in that stack because no mice ran out."

Instead of destroying snakes some farmers encourage and protect them. One Pennsylvania nurseryman turned 50 blacksnakes loose on his farm and later reported that they had rid it of mice. The Grinnells of California tell about ranchers who sometimes capture bull snakes, take them to their ranches, and release them in gopher burrows. The snakes later reappear with bulges of gophers some two-thirds the length from the head.

Unfortunately, the bull snakes are also frequently killed on roads. In San Diego County, California, Klauber found 273 dead ones along roads, or one for every 105 miles driven. Certainly most of these had been run over accidentally or unavoidably but now and then curving tracks proved that the driver had gone out of his way to get the snake. Such an act is anything but friendly to the owner of the neighboring land.

In spite of the fact that bull snakes nullify a little of the good they do by eating some birds, there can be no doubt about their great value as enemies of rodents. The highly venomous snakes of this country are in another class. The pit-vipers (rattlesnakes, water moccasin, copperhead) do some good in eating rodents and some harm in destroying birds, amphibians, and fishes, but must of course be classed as harmful. Little can be said for the coral snakes either. The other well-known kinds or groups can be roughly put into one of three lots: useful insectivorous species such as the worm, ring-necked, and green snakes, and DeKay's and the red-bellied snakes; rodent- and bird-eating species both useful and harmful such as the boas, whip snakes and racers, rat snakes, pilot black, indigo, corn, and fox snakes; slightly harmful fish- and amphibian-loving kinds, the garter, water, and hog-nosed snakes. The king snakes might be placed in a special category because they are useful in destroying both rodents and poisonous snakes but slightly harmful in devouring valuable snakes and a certain number of birds.

What I have said gives only a rough idea of the good and harm done by our common snakes. Although there are hundreds of scattered statements of what this or that species has been known to eat, this information has never been brought together. The truth of the matter is that no one knows the exact value of many of our large species. The diets of some species vary with place and season. In the spring when nestling birds are abundant, bird-eating kinds may do much harm; during the summer and fall these same species consume large numbers of rodents and are of great value. Even individuals differ, one eating nothing but birds, another only rodents, and so on.

There are some references to the economic value of snakes in the numerous publications of the United States Department of Agriculture. For every mention of the harm done by bird eaters six or eight references to the usefulness of rodent-destroying species may be found. Even after telling how destructive of birds some snakes may be, the government *Manual for Bird Banders* cautions bird lovers to "bear in mind that it is usually unwise to attempt indiscriminate campaigns for the eradication of any native vertebrate animal." Every animal should be allowed to live until its harmfulness is definitely proved and even then its extermination should be carried out under official control.

Thirty years ago the State Zoologist of Pennsylvania, H. A. Surface, published the results of the best piece of work on the feeding habits of American snakes that has ever been done. He examined 657 stomachs of the fourteen common snakes of Pennsylvania and found food remains in 278 of these. The milk snake turned out to be the most valuable, having eaten large numbers of injurious rodents and only a single bird. Next came the blacksnake with a high batting average for rodent consumption and only a few birds. The pilot black snake mixed matters up by having destroyed nearly as many useful birds as harmful mammals. The copperhead and timber rattlesnake, alas, made excellent scores with large numbers of rodents eaten and, like the milk snake, very few birds. The old saying, "There is some good in everything," certainly applies in the case of these two dangerous snakes.

In the United States one would scarcely favor general protection of rattlesnakes and copperheads on the ground that they eat rodents, but in countries where epidemic diseases spread by rats are common it would be different. The poisonous snakes might be preferable to the rats and certainly much cleaner. The common green pit-viper of the lowlands of southern China is a real destroyer of domestic rats. I saw several individuals that had swallowed these pests; one fifteen-inch snake disgorged two rats, of which one was three inches long, the other two and a half. This species probably is not deadly to man and might almost deserve protection until the astonishingly abundant rats have been reduced in number.

In British India cobra and viper venoms are used by Hindu doctors to treat many diseases. Although generally taken in pills they are sometimes given with the fresh juice of sugar cane. Some people even take small doses regularly to gain fancied protection from certain poisons and diseases. This eastern use of snake poisons is not very ancient.

I have never read how or why the Hindu doctors started the use of snake venoms but the following story of their introduction into western medicine is well known.

A little over a hundred years ago a German named Constantine Hering penetrated into the forests of northeastern South America to become acquainted with the Arawak Indians there. He heard stories about a snake so deadly that its bite would cause almost instant death. Being a student of homeopathy he at once made great efforts to secure a specimen of this fearsome reptile. Homeopathy, in its primitive form, prescribed minute doses of such medicines or poisons as produced in a healthy person symptoms of the disease being treated. In simpler words, it taught that like cures like. Hering's plan was to swallow some of the venom of this snake and then prescribe it as a cure for any disease that affects a patient the way the venom affected Hering himself, if, indeed, he lived long enough to record his feelings.

After some delay the Indians brought a specimen in a box but were so terrified that they ran away after dropping the box before Hering. This courageous man then made the snake bite a lump of sugar and swallowed venom, sugar and all. He became at once delirious but recovered completely and wrote down what he could recall about the effects the bushmaster poison had had on him. (The snake was certainly a bushmaster.) Soon after this experiment Hering introduced snake venom to the homeopathic doctors who promptly made of it a standard remedy. The poisons of the timber rattlesnake and cobra as well as that of the bushmaster have been used by them since Hering's time. One may buy highly diluted timber rattlesnake or bushmaster venom in homeopathic pharmacies of New York City today. The poison yielded by one snake at a single "milking" is enough to make many tens of thousands of doses.

In spite of all this, most doctors believe that snake poison does not take effect unless injected directly into the flesh or into a blood vessel. No one can say what made Hering delirious, but it could hardly have been the poisoned sugar. Colonel M. L. Crimmins, the noted authority on poisonous snakes of the United States, once had to collect venom from several scores of rattlers in a very short time. After milking some ten large specimens he decided that there was enough poison to be removed to a vial for safekeeping. He tried the usual method of sucking the deadly liquid up into a pipette or long glass tube but the pipette happened to be stopped up and the venom would not come up into it. Being in a great hurry he did not pause to clean the tube but sucked the harder. Finally, the venom came up—and went down Colonel Crimmins's throat. Instead of stopping to worry—as some people might have done—he at once began on the next series of rattlers. He suffered no ill effects.

During the last few decades research doctors have been attempting to cure many diseases by the injection of venoms in minute doses. Thus, at last, the poisonous snake may prove itself worthy of a permanent place on our planet. There are still differences of opinion, so one cannot yet say that venom treatments will be generally accepted by the medical world.

Venoms are used chiefly in fighting epilepsy, cancer, and excessive bleeding, but asthma, chorea, arthritis, and many other diseases are also treated. A lot of work on epilepsy has been done in this country with rattlesnake venom and in South Africa with viper venom. Some extravagant claims have been made. Among the most promising results of all are those that have been obtained in the treatment of malignant tumors or cancer. This work was largely developed in France but is now being carried on in the United States as well. The proper injections of cobra venom, according to its advocates, bring relief from the severe and stubborn pain caused by cancerous growths without being habit-forming or producing other bad after-effects. It is even claimed to be better than morphine. The venom of the water moccasin is now being found effective in controlling certain types of excessive bleeding.

Snakes themselves would undoubtedly like to spread the news of the healing powers of their venom and let the farmer know how many harmful rodents they eat. The good they do makes man offer protection, so the more people who know about it the better for snake and man alike. In strong contrast to all this are two uses for snakes that cost the lives of many of them. One is so ancient and widespread that I have described it in a special chapter on snakes as medicine; the other is fairly new and will be dealt with here. It is the use of snake hides as leather. This is a subject that a snake lover quite naturally hates to consider. The tanner has never learned to do his work without destroying nearly all of the original beauty of the snake's skin—he truly turns it into a hide.

The newer a subject the harder it is to learn about it because discoveries and advances are constantly being made and no one has had time to bring all the known facts together. This is just the case with the snake hide business; one can find little besides brief, sketchy magazine articles. The only scientific treatment of the subject that I have found was published in 1933 by the Imperial Institute of London and describes the commercial collection of reptile skins chiefly in the British Empire. The most interesting facts brought out by this report follow.

Reptile skins in general have hard-wearing qualities and are even stronger than sheep, goat, or calf skins. They have a variety of patterns and can be finished in any color, whereas only the best goat skins take color. A regular trade in reptile leathers did not develop until 1926 although Javan and South American lizard skins were in commerce eighteen years before that. The trade grew by leaps and bounds after 1926 until, in 1932, millions of skins were sent out of all the large producing countries. The Dutch East Indies exported 1,600,000 snake skins in 1931. In 1933 the collection of reptile skins had been organized commercially in India, Ceylon, the Dutch East Indies, Siam, Brazil, the Philippine Islands, and parts of Africa.

The report lists by countries and continents the kinds of snakes taken for their skins. Africa furnishes 4; Asia, taken with the East Indies, New Guinea, and Melanesia, 18; the Americas together, 16; and Australia, 3. These figures indicate that not more than one out of every sixty of the existing kinds of snakes had entered the leather markets by 1933. The vast majority of species are of course too small to interest the hide hunter; various peculiarities disqualify others. For example, a skin with large overlapping scales is troublesome because the scales refuse to lie flat. In general a skin less than eight inches wide is not used. This fact explains why the United States is not even listed among the snake-producing countries of the New World.

The report concluded that the reptile leather industry had been permanently established and compared it to that based on goat, calf, and sheep skins. In the United States, at least, such has not proved to be the case. Snake-skin products especially have gone out of style, and leather men tell me that one could scarcely sell a single snake hide to a New York dealer in 1936. But no one knows when snake-skin shoes and pocket books will be fashionable again.

Snakes are used in many incidental ways. They are to be seen on exhibit in zoos, carnivals, and circus side-shows as well as along tourist routes in the southern and western states. Not a few are sacrificed in the novelty business. Many people find them interesting pets. Common species from all over the world may be bought in European animal stores. American dealers also handle foreign kinds, but many concerns in this country are located in its southern half and sell only domestic snakes. One Florida circular at hand lists forty-three native species at prices ranging from fifty cents to five dollars, except one kind which is valued at eight. Delivery of living specimens is guaranteed.

Some of my American friends have laughed when I told them of the snake-eating habits of the Canton Chinese. Now that canned rattlesnake meat can be bought readily in New York these friends cannot laugh at the eastern love of snake meat with such a free conscience. It is just another case of our learning to do something that the (Canton) Chinese have been doing for hundreds of years.

3

SIZE

THE BOA constrictor of South America and southern North America is popularly known as *the* giant among snakes. This belief is so widespread that some circus men call all giant snakes "boa constrictors" to avoid disappointing their audiences. The true boa constrictor is exceeded in length by several other snakes, for its adult length is only eight to thirteen feet.

The krait of India stands in strong contrast to the boa constrictor. Instead of being smaller than believed the krait is actually larger than most people would have it. Kipling seems to be to blame for this. In his fascinating story of Rikki-tikki-tavi, the mongoose, he describes the "Karait" as a dusty brown snake lying by choice in the dust. When attacked by Rikki-tikki this Karait struck out viciously. Now, true kraits are neither dusty brown, nor especially small, nor frequenters of "dusty earth," and they never strike out like most other snakes. The saw-scaled viper does, however, exactly fit Kipling's description of the Karait and is undoubtedly the snake that Rikki-tikki killed.

Sea snakes are generally three or four feet long when fully grown, but one kind reaches a length of nine feet. Even a nine-foot specimen is a mere midget compared to the fabulous sea serpents. These so-called "serpents" should be known as "sea monsters"; certainly no true sea snake was ever to blame for starting or supporting the sea serpent myth. There is no reason to believe that gigantic snakes ever swam the oceans even in prehistoric ages.

So far I have told you only what not to believe about the size of snakes, but now I am going to be more constructive and tell you what to believe. This, however, is not easily done because of the scarcity of reliable information. There are three main reasons: First, persecution by man invariably brings about a decrease in the average size of large species of wild animals; therefore, the giants among them occur only in the most inaccessible regions and are as readily found as the proverbial needle in the haystack. Second, so-called record individuals invariably shrink at the approach of a yardstick. Third, measurements of large snakes are more often than not based on hides. A fresh thirty-foot python skin can easily be stretched to make a forty-foot hide. Mr. Loveridge proved this by skinning a rock python 7 feet 2 inches long without purposely stretching the skin, which was found to measure 8 feet 8 inches when dried.

There are two hard questions that I know you especially want me to answer: how long was the longest snake that ever lived, and how long does the largest living snake grow to be? These questions really cannot be answered although we can "make a stab" at doing so. The few big fossil snakes so far discovered do not indicate that snakes of past ages were a great deal longer than those alive today. The two largest known fossil species belonged to the boa-python group and probably reached an average length of a little over thirty feet. They were, therefore, somewhat larger than the reticulate python, probably largest of the living species. See the illustration of the fossil from Patagonia facing page 24.

The maximum length of the living reticulate python may be put down as thirty-two or three feet, its average length twenty feet or even less. The anaconda of South America is generally given second place with an extreme length of twenty-eight feet. Some believe that it, not the reticulate python, is the longest of living snakes.

I do not intend to devote a great deal of space to this question of greatest length because, though interesting, it is not really important; there are much more fundamental things about size to be considered. Moreover, I know of no part of herpetology that involves more conflicting "facts" than this very question of greatest dimensions. If you get another book on snakes you will certainly find statements contradicting some of those made in this chapter. Before dropping the subject I want to give the names and lengths of the largest snakes found on each of the great land masses of the earth, and list them in probable order of extreme size:

Europe and Asia: reticulate python, 32 feet
South America: anaconda, 28 feet
Africa: rock python, 25 feet
Australia: diamond or amethystine python, 20 feet
North America: boa constrictor, 13 feet

Coming to the poisonous snakes and beginning with Australia, the taipan of that continent and of New Guinea rates first mention. It attains a length of nine feet or more and can exhibit a ferocity that inspires dread. When angry it coils, keeping one or two of its coils raised well above the rest, waves its erected tail to and fro, flattens its body so that the backbone forms a ridge, makes its jaws stick out on either side, and then delivers several hard bites in rapid succession. After this it takes hold, lets go and strikes some more. The fangs are long and curved. Fortunately this dangerous creature is rare.

A Dyak hunter killed a king cobra in Siam and with his gun barrel measured its length as 18 feet 4 inches. This stands not only as the record length for the king cobra but as the greatest length that a poisonous snake has been known to attain. Lengths of over fifteen feet have seldom been proved so the specimen found by the Dyak hunter was itself a giant. No other poisonous snake of Asia rivals the king cobra in either length or ferocity. It occasionally attacks without provocation, and brooding females are especially sensitive. Jungle paths have been temporarily closed after these snakes have selected a nesting site too near them.

The taipan of Australia and the hamadryad of Asia (see the illustration facing page 25) are truly dangerous snakes, but in repose both of them appear harmless enough. The largest, though not the longest, poisonous snake of Africa, the Gaboon viper, is generally considered to be the most awe-inspiring serpent alive. This creature has a broad head, astonishingly thick body, a gorgeously intricate pattern, and fangs an inch and a quarter long (see illustration facing page 151). It usually measures three or four feet from tip to tip but may reach a length of five and a half. Instead of being ferocious it is remarkably good-natured and under no circumstances will it attack. In fact it can sometimes be picked up by the body and carried about with relative safety. It is not easy to understand why Nature has armed this snake with enormous fangs and poison glands and then given it a disposition that makes it reluctant to defend itself.

The bushmaster of Central and South America is not only the biggest of all true or pit-vipers but the largest poisonous snake of the New World. Its maximum length is about eleven feet. The diamond-backed rattlesnake of the southeastern United States takes the prize for America north of Costa Rica, where the bushmaster's range ends. It grows to be eight feet long.

The taipan for Australia, the hamadryad for Asia, the Gaboon viper for Africa, the bushmaster for South and Central America, and the eastern diamond-backed rattler for North America above Costa Rica; these are the poisonous record-breaking giants of the serpent world.

Two pythons studied by Dr. Benedict were each about 16 feet long and weighed approximately 70 pounds. This is the normal weight of a ten-year-old boy four and a half feet tall. These pythons were rather light, for Loveridge determined the weight of a 14-foot rock python as 130 pounds and Ditmars examined a 19-foot anaconda that tipped the scales at 236 pounds. This anaconda gave birth to seventy-two young, each 3 feet 2 inches long, a fact that certainly helped to account for its great weight. Hagenbeck's 28-foot reticulate python weighed just 250 pounds. The reticulate python "Rex," exhibited in New York City by the "First International Snake Exposition" of 1936, measured 27 feet 3 inches and weighed 191 pounds 1 ounce. No one among 4378 contestants who guessed its weight for a prize, gave the right answer even though the winner came close with his estimate of 192 pounds. One person guessed three tons! The largest snakes, then, weigh about as much as heavyweight prize-fighters.

Only a few kinds of giant snakes exist, so with them guesses of weights for given lengths are relatively safe. Coming to the multitude of small serpents one finds that estimations are out of the question because the degree of variation is so great. For instance, a western diamond-backed rattlesnake 4 feet long weighed just 4 pounds, whereas a long-headed snake less than two inches shorter weighed only 1.05 ounces. The western diamond-backed rattler is, then, some sixty times as heavy as a long-headed snake of equal length. A western diamond-backed rattlesnake weighing just over 6 pounds is illustrated facing page 25.

The skeleton of a five-foot rattlesnake weighs a little more than one tenth as much as the entire snake. This proportion would probably hold fairly well for other equally thick-bodied snakes.

Just as the pythons and boas are by far the largest of snakes, so the worm-snakes are the very smallest. The latter belong to two groups or families both of which are widely distributed over the earth. The larger group (Typhlopidae) is not found in this country, the smaller (Leptotyphlopidae) occurs only in the southwestern states, where three species are found. Species of the latter are on the whole much smaller than those of the former and are therefore the very smallest of snakes. The giant among them lives in tropical America and grows to be all of fifteen inches long. Most of the species do not reach a length of even eight inches and many measure only four to five from snout to tip of tail. The little creatures are thought to be earthworms by many persons and surely they resemble them in size and shape.

No one knows why snakes vary so much in size, but it is possible to tell a little about what size means to a snake, how it helps or hinders in different ways.

It goes without saying that a large snake cannot hide itself as readily as a small one. Many a python would have escaped death after a heavy meal if, like Alice in Wonderland, it could have shrunk to a tenth its size and crawled under a log or into some leaves. The python gains in ability to overpower prey through its size but doubtless has great difficulty in finding hiding places. On the other hand, a small snake readily conceals itself but cannot eat as great a variety of things as a large one.

As a snake increases its size it escapes certain enemies. The king snake does not hesitate to attack and eat snakes noticeably smaller than itself but seldom molests those much larger. This same rule would apply to most potential enemies, for the larger a snake the more dangerous it appears to be, especially if, like so many kinds, it inflates itself, hisses and puts up a great show of fight. A poisonous species becomes more and more dangerous as it increases in size; not only does it produce more venom to be injected at each bite but its reach becomes greater.

Finally, snakes that grow to be more than eight inches in circumference are now in danger of extinction at the hand of man, eight inches being the minimum width of skins in the leather market. One may see in commercial leather exhibits hundreds of hides of the beautiful reticulate python and the karung of southern Asia and the East Indies. The destinies of animals take such sudden turns! Large snakes have roamed the earth for possibly a hundred million years, yet I doubt that a more fatal blow than this recent popularity of their skins for leather has ever been dealt them. Most unfortunately, it is the harmless, not the poisonous, ones that are being slaughtered in greater numbers.

Rate of movement is also more or less dependent on size. A six-inch snake could not be expected to race one eight feet long. This factor would be of importance in escape from enemies as well as in pursuit of prey. Choice of habitat can also be correlated with size although form or shape is more important in this regard. Heavy, thick-bodied snakes sometimes live in trees, but the lightest, slenderest ones are by far the most agile climbers (see the illustrations facing page 81).

The tiny worm-snakes well illustrate some advantages of extremely small dimensions. They are masters in the art of concealment. On the Island of Hainan, China, we found them abundant under small flower pots. No wonder, then, one species has been carried all over the earth by man in cargoes of boats. Incidentally, a worm-snake is much harder to hold than a snake four or five feet long. The hard smooth scales and great strength of the tiny creature enable it to slip through one's fingers in the most astonishing way. Holding several of these snakes is a little like squeezing a handful of mush. It is not surprising to learn that these animals are excellent burrowers and we cannot doubt that their small size, smooth scales, and great strength were developed along with their subterranean habits.

The female of most species grows to be both longer and heavier than the male, although there are enough exceptions to make the subject interesting. In some species the difference between sexes is so marked that the sex of adults can be guessed even at a distance with a high degree of accuracy. Oddly enough, information on male and female lengths of American snakes is not easily found, but the common water snake of the eastern United States may be named as a species that follows the rule. A reasonable explanation of this sexual difference is that it affords the female's body extra space for eggs or young.

I have told you briefly that a certain relation exists between the size of a snake and its ability to protect and conceal itself, get proper food, reproduce its kind, choose a suitable habitat, spread itself over the earth, and avoid extermination at the hands of its arch-enemy, man. How many illustrative cases can you think of? Suppose one of the kinds of snakes with which you are familiar increased its length two feet, what animals could it add to its menu? Or, again, does your cat or dog show more fear of a small snake than of a large one? Perhaps the activity of the snake is more important in this connection although the larger the snake the more severely it can strike or bite. Your cat or dog will probably appreciate this fact. Would a full-grown DeKay's snake or a large blacksnake be more likely carried about by accident in loaded truck or boat? You doubtless can think of even better questions than these.

4

AGE AND GROWTH

IT HAS long been a habit of people living in the country to carve dates on the shells of turtles, but sometimes the date cut is incorrect and gives the turtle a hoary age that it by no means deserves. As a result much good and bad information on the turtle's length of life has been recorded. When it comes to lizards and snakes, however, we must rely almost wholly on records of captive specimens: those in zoos and others kept as pets by private individuals. There is of course objection to using such records because many snakes refuse to eat when confined and others live in environments hard to imitate. Climate alone has a lot to do with the comfort of snakes, and artificial heat and humidity do not invariably keep them in good shape. In spite of all this our zoo and private owner records are the best we have and do prove that snakes live at least this or that many years. It is not unreasonable to assume that the species best adapted to artificial surroundings will live about as long under these as under natural conditions. It is even possible that some kinds may survive longer on the average in captivity because of regular food supply and total absence of enemies.

Reptiles enjoy the distinction of including the animals that live longest of all vertebrates, the turtles. In the sense used here the term turtle includes both tortoises and terrapins. These creatures certainly live well over a hundred years but how much over is hard to discover because records dating before 1800 are relatively unreliable.

Reptiles also include a very short-lived group, the Old World or true chameleons. These strange lizards invariably last but a few years in captivity even though they are among the most popular of animals not only in zoos but as pets. It was said in 1918 of the British Egyptian Expeditionary Force that certain battalions carried as many chameleons as rifles! Among some seven hundred examples received by the London

Zoological Gardens from 1870 to 1924 only one lived over three years and three over two. In the Giza Zoological Gardens, Egypt, where the climate is more suitable than in London, just two among 206 passed the three-year mark. Up to 1925, when Major Stanley S. Flower published his excellent paper on the length of life of reptiles, from which I take many facts, no captive chameleon had been known to reach the age of four years. It is entirely possible that these animals exist much longer in a wild state but the most reasonable conclusion at present is that they have a relatively brief span of life—not over five years.

Major Flower gives a summary of his paper on longevity, listing ninety-three records of reptiles that have survived ten years and more of captivity. About half of the items are names of turtles, a fact not only indicating that turtles reach a greater age than any other reptiles but also proving that they do well in captivity. A few points of special interest in Flower's summary are given below. I have moved the place of the Chinese alligator up a little.

Number or Period of Years Lived	Name of Animal or Group
100–43	turtles only
42–40	Chinese and American alligators
31	first lizard and first crocodile to appear in list
23	first snake (boa constrictor)
22	first true viper (European long-nosed viper)
21	first python and first pit-viper (reticulate python and water moccasin)
20	second lizard (Australian skink)
19	Madagascar boa
18	rock python
16	Indian python
14	first small harmless snakes
13	first cobra and first rattlesnake

Flower concludes with good reason that "snakes appear to reach their potential period of longevity soon after twenty years."

In 1925, the same year that Flower's work appeared, Schumann published an account of a specimen of the leopard snake of Europe which had lived in the Sofia Zoological Garden twenty-five years. As far as I know this is the longest that a snake has ever survived captivity. Oddly enough, the leopard snake seldom lasts more than a year in confinement. The common water snake of Europe generally dies within two years of its capture. The record of twenty-three years for a boa constrictor given in Flower's list is based on a snake that was born July 14, 1900, and died November 7, 1923, apparently from old age. At death it measured 13 feet 2 inches. This is one of the most satisfactory records of the life span of a snake. As to family life, a brood of Indian pythons kept in the Jardin des Plantes, Paris, nearly a hundred years ago, takes the prize. One of these lived 6, one 7, three 9, one 10, one 11, and one almost 16 years.

From the following conclusions reached by Major Flower in his studies of longevity in other groups of vertebrates, it will be seen that snakes can be branded as neither comparatively long- nor short-lived creatures. Some fishes may live half a century; certain others have a normal existence of less than two years. One amphibian, the giant salamander of Japan, has been known to last fifty-two years, but in this group as a rule only the larger species live to be even six or eight years old. Birds have relatively long lives; forty species have passed the thirty-year mark in captivity and a few have exceeded fifty years. In general they survive longer than mammals. Man outlives all other mammals; only the Asiatic elephant and rarely the horse pass with him the half-century mark. Excepting a few cases at either extreme, the average age of mammals is twelve to twenty-five years.

In some groups the larger species as a rule live longer than the smaller. This seems to be especially true of the lizards, amphibians, and birds. It is hard to generalize about snakes. The records as they stand would seem to indicate that the pythons live longer than other snakes, but this may be because so much better care is taken of the former and more complete records kept. A small snake can be readily replaced but pythons are exceedingly valuable and call for special attention. To the general public snakes are easily divided into "boa constrictors" (large pythons and boas) and other snakes, and the former incomparably outshine the latter in popularity.

The best introduction to a subject often seems to be a refutation of some general but erroneous belief. In the present case I shall begin with the discussion of growth by proving that even large reptiles grow rapidly when living under favorable conditions. Many books tell us that giant turtles especially live long and grow by slow degrees. What about the Galapagos turtle or tortoise kept in California that weighed only 29 pounds in 1899 but tipped the scales at 350 seven years later? That is an annual increase of just over 45 pounds. Figures published by Dr. Charles H. Townsend, Director of the New York Aquarium, show that, once a weight of 10 pounds is attained, these huge reptiles may be expected to gain from 15 to 35 pounds a year under good artificial conditions. It is not for man to call an animal that can reach a weight of 350 pounds in fourteen or fifteen years a slow grower.

Take the American alligator. Mr. McIlhenny finds that in Louisiana 'gators are 9 inches long at birth, 40.7 inches at two years, 62 inches at four, and 6 feet at six. The weight of a two-year-old is nearly 11 pounds, a four-year-old about 25 pounds, and a six-year-old 52 pounds. The average alligator at six weighs as much as the normal boy or girl of the same age four feet tall. If we make a little allowance for the slender tail tip of the former, it is obvious that the six-year-olds in question have a certain similarity in proportional build. The alligator really grows faster because when two years old its weight does not much exceed that of the average human at birth.

The rate of growth of cold-blooded animals is complicated by the dependence of these creatures on the temperature of their surroundings. When the thermometer falls, their own temperature falls with it, and growth is slowed up along with digestion and other natural processes. In the winter they must hibernate because they cannot find a place warm enough to enable them to live at a normal rate. During hibernation, or winter sleep, growth is greatly retarded. It goes without saying that snakes in the tropics can grow about twice as many months a year as those living in temperate climates. In his studies Dr. Blanchard allows five growing-months in northern Michigan and seven in Oklahoma. Some tropical snakes are said to æstivate or sleep during the hot dry season, but there is little information on this subject and we shall consider tropical species as active throughout the year.

The most obvious way to determine the rate of growth of any animal is to keep it in captivity and take regular measurements. One objection to this is that you may get results quite different from those that you would get with animals living under more natural conditions. Captive snakes sometimes remain in good health and eat regularly but grow very slowly. How then can one discover the rate of growth of snakes living in the woods and fields and streams? There are two ways. The better of these ways, but by far the more difficult, is to mark every specimen in a region and recapture as many as possible at regular intervals for re-examination. In the course of time one can get much varied information.

The other way is to secure a large series of specimens from one region. Provided you live in a temperate climate measurements of such series will enable you to divide your young individuals into size groups. Each of these groups will include specimens of the same age. This is because in temperate climates snakes of any one place are born or hatched at about the same time. For example, Gloyd showed that in Kansas copperheads are born from August 23 through September 17 and Blanchard found that, during 1925, eggs of eastern ring-necked snakes of northern Michigan hatched from August 28 to September 11.

You can think of these young snakes as contestants in a handicap race. Suppose you started a great many equally swift runners off on a long race by successive groups and then took photographs of the entire course from an airplane. The picture would show the men arranged in those same groups as long as they continued to run at the same rate. Now suppose that the foremost groups gradually slowed down and finally came to a standstill at the goal. If you kept starting new groups and using your airplane and camera the pictures would always show separate groups near the starting point, a gradual mingling of these toward the end and, at the goal, a uniform mixture of many groups.

This is exactly what happens with the growth of snakes. Every year in the late summer thousands are born at about the same length (your starting line) and begin to grow at approximately the same rate (speed of your runners). Allowing for a few that do not get enough food or fall sick, the yearly lots can be separated by size just as your pictures show the runners in different groups. As maturity is reached and growth slows down the size groups no longer remain distinct and are finally obliterated as growth ceases (the goal).

For instance, 56 among 80 DeKay's snakes measured from 4.25 to 8.25 inches, whereas the remaining 24 were 9 to 12.75 inches long. None measured between 8.25 and 9 inches. Dr. Clausen found these snakes hibernating together on Long Island in February 1933. DeKay's snakes are born at lengths of 3 to 4.25 inches, so it is reasonable to assume that the smaller lot included only hatchlings of 1932. Since adults of this species are but 12 to 15 inches long one cannot say how old the specimens of the larger group were. It is certain from these figures that DeKay's snake matures rapidly. If it did not there would be more size groups.

In the tropics young of one species may appear over a period of months, so growth cannot be determined readily by measurements.

In this country we say that a man twenty-one years old should be educated, strong, independent, and ready for marriage. He has come of age. From the lowly point of view of a snake, only the last of these attributes has any meaning and that one in a greatly modified form. Snakes may be considered grown when they are old enough to have young, that is, at sexual maturity; they are born educated, independent, and strong enough to get their own food and drink. Even though growth continues long after they are first able to have young, this ability to reproduce is tremendously important. Animals that do not reproduce well and frequently simply do not survive.

The striped swamp snake of the central United States and DeKay's snake become sexually mature the second spring of their lives; the diamond-backed water snake of the south central states and the water moccasin probably at the third spring. It is convenient to give the ages of snakes of temperate regions by springs because, as explained above, the young quite uniformly appear in mid- or late summer. A snake that first breeds during its second spring is sexually mature at about a year and a half; one that breeds during its third spring, at about two and a half; and so on. The number of springs is one more than the age of the snake without the fraction.

The age of sexual maturity has not been determined for most American snakes. We can, however, make a good guess in many cases if we know the size at birth or hatching and the length at which females first reproduce. Let us take the case of the copperhead. Gloyd gives 9.1 inches as the average female birth size and 22.2 inches as the length of his smallest specimen that had young. If that female grew 4.2 inches during the approximate 142 days that she carried her young and, like many other snakes, had doubled her length by the beginning of her second spring, we can reasonably conclude that the species reaches sexual maturity during its second spring or when about a year and a half old. It is a fairly safe guess that most of the snakes in the United States mate when their second or third spring arrives. A species with a very extensive distribution from north to south surely matures at a somewhat greater age in the extreme northern part of its range where its annual growing period is short.

Colonel Wall studied the growth of snakes in India for many years. He found that most of the species living in tropical parts of that country double in length their first year. By the end of the second, many kinds are three times their birth length and ready to breed; others are not ready to breed until three years old. Some sea snakes appear to reach maturity in less than one year. John's sea snake, illustrated facing this page, is a remarkable creature with a ridiculously small head and neck attached to a large body. Its young at birth are approximately 14 inches long, and females with young inside are often only twice this length. There is every reason to believe that this astonishing snake mates when six to eight months old. The young of several burrowing snakes of tropical India are also born half the size of their mothers and probably reach maturity before entering their second year.

Among snakes that do not grow to be more than nine or ten feet long a fairly constant ratio exists between the length of hatchlings, the size at which maturity is reached, and the average maximum size of the females. Adult males generally run a little smaller, so special allowances must be made for them. Take the size of the hatchling, multiply it by two and a half, then by three and a half; the two figures that you get are the limits within which the length of the recently mature female should fall. The length of a hatchling added to that of the recently mature female gives you the approximate size of the fully grown female. This rule will work with a great many snakes but in some cases the female when first mating will be only two, in others as much as four times the length of hatchlings.

The growth rate of the giant constrictors under natural conditions has not been determined, but something is known about their growth in captivity. Near the middle of the last century a group of hatchling reticulate pythons started life in Paris at about 20 inches; during the first twenty months most of them reached lengths of 80 inches and one even attained 92 inches. The Indian python hatches at about 2 feet and breeds when in the neighborhood of 10 feet long. Both of these pythons are probably sexually mature when four years old, and the reticulate python may attain a length of 22 or 23 feet in fourteen years. A boa constrictor born in captivity in Australia is stated by Le Souef to have reached a length of 62 inches in two years; it was 25 inches long when hatched. In all probability one would have to make a special rule for the growth of these giant snakes in natural state. A rule something like this might apply: the birth or hatching length is at least doubled for the first year, tripled for the second, and so on for four years; at the end of this time maturity is reached. After that the length is doubled or nearly doubled before growth ceases. By this calculation a reticulate python born at two feet would breed first at ten feet and eventually reach a length of eighteen to twenty feet.

The condition of the teeth of a mammal may give a good clue to its age. The rings on the scales or bones of a fish and those on the shields of a turtle often serve the same purpose, but the age of a snake is not so easily determined. No rings are to be found on the scales and neither their number nor their arrangement changes from birth to death. A. A. Emelianov has worked on a method of telling how old a snake is by cutting slices of its vertebræ, but he has come to no definite conclusion. At best his method would be too hard for most of us to use. By being somewhat familiar with a species we can often make a good guess at the age of any individual. If our specimen is small or has a juvenile coloration we say it is young; if it is carrying eggs or embryos we conclude that it is mature; if the color pattern is faded we guess that it is old and so on. Of course only a limited number of snakes change their color with age; one must know about that in advance.

Even with rattlesnakes one can only guess at age. If these reptiles added one segment to their rattles regularly every year all would be well, but, alas! they do no such thing. Moreover, they constantly lose parts of the rattle. It is usually said that a new segment appears at each shedding of the skin, but this does not appear to be invariably the case; such correlation very probably varies in degree from one species to another. Shedding occurs twice a year or more. If a snake is found with a rattle that tapers to a point we can conclude that it is young; while a snake is growing rapidly each successive segment acquired is wider than the preceding one. Professional showmen and snake charmers sometimes attach extra rattles to make snakes appear very old. We must not be fooled by such trickery.

5

SENSES AND INTELLIGENCE

Dr. E. H. Taylor hatched out a batch of cobras in the Philippine Islands and found that the hatchlings while still only partly out of the egg would spread, hiss, and strike in a most business-like manner. DeKay's snakes but ten minutes old and four inches long have been observed to trail and devour earthworms. Thus we see that snakes at hatching or birth are quite ready to take care of themselves. They do not have to learn because strong impulses tell them what to do. Indeed, as we look at the animal scale from fish up through man, we see that the lower the animal the stronger these impulses and the less the necessity to learn. Compare a new-born human to a hatchling cobra, the one utterly helpless the other already dangerous.

Since there is little necessity for a snake to acquire knowledge it is not surprising to discover that its ability to do so is slight. Nevertheless, snakes can learn to a limited extent. For example, it has been demonstrated that some species recognize their cages or special hiding places even when shown these in new surroundings. Miss Wiley's rattlers behaved as though they certainly recognized her. One of her favorites, "Huckleberry Finn," arched its back only while being stroked by her and it often crawled up to coil by her chair when she had it out on the lawn for a sunbath. She had won its confidence by consistently gentle treatment. This snake was so tame that it would lie coiled in her lap "like a contented old cat" while she sewed in the evening.

Dr. Ditmars rates cobras as the most intelligent of snakes. He describes experiments to test their mental ability and tells how one individual that had to be caught every day for treatment learned to turn away from the side on which Keeper Snyder held his snake stick as he approached for the capture.

During the last score or more of years scientists have paid much attention to the ability of animals to learn. Literally thousands of experiments have been conducted with white rats as the prime "goats." A common procedure is to see how long it takes a series of individuals to remember the way out of a maze or labyrinth. Food is generally offered as the reward for a successful escape; failure may be punished by electric shocks or other unpleasant sensations.

Reptiles have been largely neglected although turtles have come in for a limited share of experimentation. Only one such study has been made on snakes. At the University of Indiana, W. N. Kellogg and W. B. Pomeroy built a water maze which was arranged so that a snake by making three correct turns and crawling up a short incline would escape from the disagreeable cold water of the maze to a goal containing pleasantly warm water and a dish of dry earth. Eleven young common water snakes and their mother were used. Every specimen was given from 62 to 73 trials but no snake was put in the maze more than once on the same day. All the snakes had not mastered the maze when the experiment was brought to a close at the end of three months and nineteen days. The family as a whole showed typical learning although improvement was irregular. This irregularity was in part due to the periodic shedding of the skin, which obviously had a bad effect on the memory. It is possible that this effect was more apparent than real because the loosening skin may have made the snake less sensitive to change in temperature. Another point brought out is that the mother did no better than many of her children. Her age was not known but the youngsters were only four months old when the experiment began. A mother water snake apparently has only "the sense she was born with," which, after all, is more than some human beings appear to have.

Whether guided chiefly by intelligence or by blind impulses, all vertebrate animals have much the same gateways to the outside world. These gateways are the sense organs and, taken together, they are indispensable parts of an animal. However, none of even the primary senses is necessary if enough other gates are open: this species gets along perfectly without eyes, that one without ears, and so on. Sometimes a sense is not developed because the animal could not use it if it were (cave-dwelling creatures have little need of eyes); in other cases it is simply not developed—no one knows why. The relative importance of one sense to another also varies. The senses in snakes as a group differ greatly from those in man and other mammals and are therefore especially interesting.

The forked tongue flicked out by a serpent is perhaps the most misunderstood part of the most abused of animals. Scientists have corrected the popular belief that it is a "stinger" only to describe it erroneously as an organ of hearing. In addition to being a simple feeler, the snake's tongue is actually an instrument by means of which objects are smelled. I say "by means of which" because the tongue itself can smell no more than it can taste; its tips carry dust particles from the air or minute bits of anything they touch into two tiny cavities in the forward part of the roof of the mouth. These cavities, together with their walls, are called Jacobson's organ. A study of its embryonic development proves Jacobson's organ to be an offshoot of the smelling area of the nose, so it is reasonable to conclude that the sensation perceived through it is nearer to smell than to taste. A snake, then, cannot taste but can smell either with its Jacobson's organ assisted by the tongue or with its nose alone. Even in a hatchling, however, the sensitive area in the nose is no longer connected with the Jacobson's organ.

There is some difference of opinion as to whether the nose or Jacobson's organ is the more valuable to a snake, but all workers agree that, taken together, these organs are indispensable. Clausen and Noble believe that at least in common garter and DeKay's snakes the nose is more important. They found that one DeKay's snake ordinarily recognizes another largely by use of the nose and, when blindfolded, readily follows a trail made by rubbing another individual along a smooth surface. Sight helps in recognition but the tongue and Jacobson's organ play no part. Other experiments proved that common garter and DeKay's snakes follow food trails by using both the nose and the Jacobson's organ but depend more on the former than on the latter in doing so. Food trails were made by smearing earthworm extract along the surface of a smooth stone; they were of course invisible. Such an extract is prepared by grinding up earthworms, adding a little water, and filtering off the liquid or extract.

A snake has a "glassy stare" only because the eye is covered by a transparent cap that cannot be moved. This cap is nothing more or less than eyelids that have been transformed into a permanently closed window. The eyeball inside this window is movable just as yours is. Nearly all snakes focus or shift the gaze from a near to a distant object or vice versa by changing the position of the lens; you do this by altering the shape of your lens while keeping it in the same position. The eye of a snake is especially constructed for focusing on nearby small objects.

Gordon L. Walls accidentally ruptured the eye of a European snake which he was studying and noticed that the lens was yellow. Realizing that, at the time, only one other vertebrate, a European squirrel, was known to have a yellow lens, Walls went into the matter carefully. He was rewarded by finding yellow lenses in many active snakes that prowl by day. Moreover, the colors of their lenses match various grades of "Noviol." Now Noviol is a kind of glass used in making spectacles and goggles worn by huntsmen to increase their acuteness of vision. This special glass absorbs the violet end of the spectrum and thus cuts out the unequal refraction characteristic of that end. It is highly probable that the yellow lenses of snakes improve their sight in this same way.

The adaptation of snakes' eyes for night and day vision is especially interesting. In any eye the retina is the photographic film that starts impulses along nerves toward the brain to produce sensations of sight. Two types of cells are present in this film, the rods and the cones. Cones suffice for daylight activity but rods are necessary for vision at night. The presence of rods calls for an especially efficient means of shutting out bright light because a retina with only rods is easily blinded by dazzle. An eye containing cones and no rods readily stands any ordinary intensity of light. As you know, the amount of light to reach the retina is regulated by the iris or shutter of the eye and the opening in the iris is the pupil. You can see your shutters work by closing your eyes for several seconds and then opening them in front of a mirror. It has been shown that a round pupil cannot be closed as completely as an elliptic or slit-like one. A simple formula will help you to keep in mind these relationships:

> Only cones = day prowling, night blindness = round pupil.
> Only rods or rods and cones mixed = entirely or chiefly night prowling = elliptic pupil.

Snakes make use of both types of pupil, and field studies have shown that species with up-and-down elliptic pupils are nocturnal, but those with round ones prowl during hours of light. There are exceptions, certain round-pupiled kinds being known to be active at night. Such species are certainly blind in the dark and must depend on other senses than sight during their nocturnal wanderings. This is a striking case of an animal failing to use a perfectly well-developed organ. With few exceptions the true and pit-vipers and boas and pythons have elliptic pupils and are active at night. Taking snakes as a whole, however, there are more species with round than with elliptic pupils. Unlike the vast majority of mammals, most snakes prowl by day.

In the United States the few kinds of boas, all quite harmless, and the highly dangerous rattlesnakes, water moccasins, and copperheads have elliptic pupils. With five exceptions our other native species have round pupils. The exceptions are the spotted night snake, the annulated snake, and the three species of lyre snakes. All these are chiefly southwestern in distribution, and none of them occurs east of Texas.

Everyone has seen pictures from India of cobras "dancing" to the music of snake charmers. On the other hand anyone who has hunted snakes has noticed that a basking specimen is not frightened away by talking or even shouting. In an attempt to find out whether cobras actually do hear, Colonel Wall covered the eyes of several individuals with adhesive tape and then made various sounds in the air near them. He could arouse them no more by blowing a bugle than by beating on a large empty tin can close to their heads. If, however, anyone moved a chair or walked along near by, the snakes immediately reared. This plainly showed that any hearing was the result of vibrations carried through solid bodies in actual contact with the snakes. You can hear in the same way a distant train by putting your ear to the track. As a matter of fact sounds transmitted thus travel faster than those carried by the air. The Indian snake charmer is careful to move his arms or legs incessantly or to sway the trunk back and forth while performing, and it is this rhythmic motion that "charms" the highly sensitive cobras and makes them appear to be dancing to the music.

It is not surprising that snakes are so indifferent to vibration of the air because, although possessing good inner ears, there is never a trace of outside ear or eardrum. A snake's ears are as hard to find as its hips, though the former are of general, the latter of rare occurrence. The bone known as the stapes or columella that would serve to carry vibrations from an eardrum to the inner ear is buried in muscles and connected to another bone that moves whenever the animal is eating. Scientists have said that a snake must hear a terrific noise while swallowing. It is more likely that the stapes has lost its ability to transmit sound waves.

Animals that sing or have varied calls are generally able to hear well because communication between individuals is one of the chief uses of sound. Thousands of species of mammals and birds could be named as good examples. Snakes illustrate the reverse conditions. Indeed there is little evidence that snakes hear noises made by other snakes. The most probable exception is the aquatic karung of the East Indian region, which is known to make a loud *b-r-r-r-o-t* that can be heard at a distance of more than a hundred yards. There is no reason why such a sound should not travel through the water from one snake to another.

The most persistent noise makers among snakes are of course the rattlers. Some of these are extremely nervous creatures and sound their warning at the slightest disturbance. This makes them ideal subjects for hearing experiments. Shortly before his death in a train accident, F. B. Manning selected some especially sensitive rattlers and tested their ability to hear. The appearance of even one finger from behind the blind concealing Manning from his subjects would cause at least one specimen to rattle. Nevertheless, the vast majority of individuals could not be induced to rattle by a loud noise made within a few inches of their heads.

An occasional one responded to notes of very low pitch, 43 vibrations per second, or two and a half octaves below middle C on the piano. The most irritable snake of all rattled at sounds of 86 as well as 43 vibrations. Like Wall, Manning concluded that his snakes were deaf in the ordinary sense of the word and doubted that any rattler has ever heard another rattle.

The experiments by Manning are especially significant because the rattlesnake is a pit-viper and it is entirely possible that the low sounds responded to by some of his specimens were perceived through the pit and not the ear. The pit is a complex organ lying between the eye and nostril. It consists of two cavities separated by a thin membrane. The outer cavity is readily seen and freely open to the outside but the inner one is concealed and closed except for a tiny hole or pore just in front of the eye. Judged by its structure, the pit is some sort of organ of hearing. The puzzling thing is that no one has ever conclusively proved pit-vipers able to do anything that cannot be done just as well by true or pit-less vipers. Many possible uses have been suggested for the mysterious pit. The most enticing and groundless explanation of all was advanced in 1868 when Leydig called it an organ of a "sixth sense."

Dr. W. Gardner Lynn, who has written the best description of the problematic pit and is experimenting with hearing in snakes, writes me that he by no means considers either the question of hearing in snakes or that of the function of the pit exhausted. It may yet be shown that some snakes can hear vibrations of the air through the pit—or even without it.[1]

Let me briefly summarize what I have said in this chapter and compare you to a snake. Intelligence, in the sense of ability to learn, is your most important faculty; a snake has but little intelligence of this kind and does not seem to mind. Smell ranks first with a snake but last with you. Moreover, a snake can smell in either of two ways. If a python felt especially cheerful he would say his affairs were "smelling up" rather than "looking up." Vision is about as indispensable to you as to a snake, but you see better at a distance. Hearing in the ordinary sense, as well as communication by sound, is all but unknown in the serpent world. A snake's tongue is a feeler and an assistant in smelling, yours chiefly a manipulator of food and a taster.

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[1] Since this chapter was written, a paper by Noble and Schmidt has appeared describing experiments indicating that the pit enables the pit-vipers to discriminate between warm and cold objects moved in front of the head. The depressions in the lips of certain boas and pythons seem to have the same function. In a state of nature these pits and depressions presumably assist in the detection of warm-blooded prey. The authors confirm the earlier conviction that the pit is also able to detect some air vibrations.

This comparison no doubt makes you glad that you are a nearly hairless mammal known to science as *Homo sapiens* and to your mother and father as John or Jim. If you were a snake, however, you would never have an earache or get dust in your eye.

6

FEEDING

WHILE WALKING by a rock-faced terrace in central China one day I heard a noise that sounded suspiciously like a snake hurrying away through the rocks. I then caught a field frog, tied a string to it, and left it tethered among the loose rocks. Returning a little later I found a Chinese chain snake with the frog in its stomach and the string holding it fast. This trick does not always work because many snakes either will not swallow the bait or throw it up too quickly upon being approached.

In northern China, many months before, I had bought one of these same snakes from a Chinese who had discovered it in the act of swallowing a pit-viper about half its own size. In still another Chinese locality, I fed captive individuals on frogs and toads, geckos and other lizards, young birds, and small harmless snakes. I took fishes and skinks from the stomachs of preserved specimens and a guinea-pig was found in one caught in Nanking.

The appetite of this snake rivals that of the water moccasin of the United States. Conant's moccasin was fed on frogs, snakes, birds, rats and mice, both wild and domestic, and salamanders. Lizards and young turtles have also been eaten by the species. Although it is best to use records of food consumed only under natural conditions there is little doubt that the Chinese chain snake and the water moccasin eat in a wild state the variety of animals indicated here. The appetites of these two ophidians are about as varied as those of any snakes. They will serve to illustrate the tastes of species with no tendency toward specialization of feeding habits. The blacksnake and blue racer are additional North American snakes with catholic appetites.

At the other extreme are a few snakes which confine themselves to very limited diets. The best example is the famous egg-eating snake of Africa and Arabia. Large specimens of this reptile are only thirty to thirty-two inches long and yet they can swallow a hen's egg! Ordinarily adult examples eat eggs of birds. The egg is seized and swallowed quickly but with noticeable effort. When it reaches the throat, contractions of muscles cause the projections extending from the vertebrae through the walls of the œsophagus to pierce the shell. Continued contractions crush the egg and force it on down the throat. The shell is soon stopped by a constriction just before the stomach and later disgorged. The teeth of this snake are small and weak especially toward the front of the jaws. In the young the teeth are better developed and different food is probably eaten, for obviously there is a lower limit to the size of bird eggs.

One could not ask Mother Nature for a more beautiful example of specialization in feeding or of correlation between structure and habits. It is interesting that certain species of a group of Asiatic snakes like to eat reptile eggs and lack teeth on the front tips of the jaws. Eggs seem to be good food for toothless snakes just as—when soft-boiled—they are good for toothless humans.

One has to search far and wide for every example that rivals the egg-eating snake, but moderate degrees of specialization, even of whole families, are not rare. For instance sea snakes seem to confine themselves to fishes, another group to slugs and snails, and certain burrowing Indian snakes to earthworms. There are closely related species that avoid competing with one another by choosing different kinds of food. In parts of eastern Asia two snakes of the genus *Enhydris* live side by side in the flooded rice fields; one eats only frogs, the other nothing but fishes.

Most snakes draw their food not from one group of animals but from three or four and thus fall in between the general and the specialized feeders. Such combinations as fishes and amphibians, birds and mammals, snakes and lizards, are popular though a third group is more than likely to be included.

In cutting open hundreds of preserved snakes from China I found it necessary to be careful to examine the stomach and intestines as a whole because the remains of a frog's insect food will linger after the frog itself has nearly or entirely disappeared. If judgment is not used every frog-eating snake will sooner or later be recorded as insectivorous or at least as invertebrate-eating. The dissecting of stomachs in search of food records is fascinating; one is making a dead creature tell secrets, and sometimes very surprising results are obtained. Hay's snake of Florida, a relative of DeKay's snake, was first found in the stomach of a coral snake. Boulenger cut open a South American coral snake which held another snake which in turn had eaten a kind of snake-like amphibian or cœcilian new to science. If you cut far enough there is no telling what you may discover. Snakes found dead along the road are good material for such dissections but you must be prepared to find many empty stomachs.

Having so recently studied the feeding habits of Chinese snakes I know no better way to illustrate the food preferences of snakes of a large area than to give a table summarizing the food of eighty-two Chinese species and subspecies. Nothing eaten by captive snakes was counted in making this summary. The groups or kinds of animals eaten are listed on the left; the number of snakes known to eat each group or kind is indicated by the opposite figures on the right. Do not forget, however, that most snakes eat more than one kind of food.

Frogs (including toads)	33
Lizards	25
Mammals	21
Snakes	12
Birds	9
Fishes (general)	7
Eels and Loaches (elongate fishes)	6
Earthworms	6
Slugs and Snails	4
Reptile Eggs	3
Crustaceans	2
Spiders	2
Insects	2
Whip-scorpion	1

Frogs are obviously the chief victims of this list! However, if we consider lizards and snakes together as elongate reptiles, they give the frogs a good run and well surpass the mammals. It is interesting that the total number of kinds feeding on snakes and lizards taken together is only twenty-eight. I have explained elsewhere how conveniently both lizards and snakes are shaped as food for the latter. The great fondness of Chinese snakes for frogs may be due in part to the vast areas of rice culture in eastern Asia. The beautifully terraced and flooded rice fields are regular frog hatcheries and, for snakes, free lunch counters. Also eels and loaches are common in these irrigated regions. Like snakes and lizards these elongate fishes are conveniently shaped food, a point not overlooked by several Chinese snakes.

Dividing these food items up into vertebrates (fishes, mammals, birds, reptiles, and amphibians) on the one hand and invertebrates on the other, I find that only thirteen Chinese snakes are known to eat invertebrates whereas seventy-one eat vertebrates. This means that but two kinds eat both vertebrates and invertebrates. In the United States not only do many more species eat invertebrates but numerous kinds like both groups. The copperhead, various water and garter snakes, and some whip snakes and racers are examples of American snakes with a fondness for both vertebrates and invertebrates. When the habits of Chinese snakes are better known more species will certainly be added to the invertebrate eaters.

All snakes live solely on animal food. This is one rule without an exception. A herbivorous species has yet to be discovered.

How do snakes manage to catch such active, alert animals as mammals, birds, and lizards? Before giving the snake too much credit we must bring to mind what natural advantages it possesses. In the first place its shape enables it to present a very small "front" while moving forward. Imagine yourself a mouse in tall grass. Don't you suppose that the approach of a large snake would be harder to detect than that of an equally heavy mammal? Every inch of a snake follows the inch just ahead, so very little grass has to be pushed aside to permit an advance. This means that relatively little noise is made. In fact a snake depends a good deal on a stealthy approach; certainly it would have little chance to overtake in the open many of the animals upon which it preys. Think of a rattlesnake running down a rabbit!

Keepers in zoos say that pythons become restless and crawl about their cages when they have not eaten for a long time. This is undoubtedly what snakes do in a wild state, and such activity sooner or later brings them in contact with something to eat.

Wall discovered a large Chinese field snake hunting for frogs and states that "it was most interesting to notice the method and care with which it beat the patch of grass like a harrier, prying into every recess in the ground or tussock that might harbour some possible prey." On other occasions he saw examples of this same reptile coiled up on banks near water in which frogs were noisily breeding. This species apparently may either lie in wait for food or actively search for it. Van Denburgh often watched the common king snake in the southwestern United States climb up several feet to look into birds' nests which sometimes proved to be empty. In Nevada, Richardson found about a dozen western garter snakes at the foot of a dam gorging themselves on fishes which were running in great numbers.

Common king snakes of the Okefenokee Swamp in southeastern Georgia are fond of turtle eggs. Wright and Bishop believe that the turtles were at times actually followed by these snakes apparently in hopes that eggs were about to be deposited. This is ophidian optimism with a vengeance. As many as fourteen eggs were found in the stomach of one common king snake. This also illustrates how a snake may make use of an especially good food supply; certainly over much of its range this species rarely gets a chance to eat turtle eggs.

Most snakes find their food by relatively simple methods of hunting such as those described above. A few species have developed more complicated ways. For example, the bull snake is able to capture rodents, such as pocket gophers, in their subterranean homes. In excavating their main burrows these mammals carry soil to the surface through lateral tunnels which are finally filled with loose earth. The snake gains entrance to the main burrow by re-excavating the lateral tunnels. This it does by repeatedly pushing its head into the earth and bringing out in a coil of its body all the soil that it has succeeded in loosening. Once in the main burrow, the snake kills the trapped pocket gophers by pressing them against the walls of their abode with its body, a method that, in confined quarters, takes the place of constriction. In describing the behavior of the bull snake outlined here, Hisaw and Gloyd state that a single one has been known to kill at one time three half-grown rats. A captive rat snake or dhaman in India was once observed to kill a rat by pressing it against a python and the floor of the cage. This is a rather unusual use for a python.

Even sea snakes are reported to have their tricks. Some fishes have a habit of collecting about any small floating object. A sea snake swims to the surface and floats motionless until several unsuspecting fishes have gathered about it. A sudden lunge and the population of that region is decreased by one fish.

On June 4, 1923, five young were born to a captive hump-nosed viper, a species inhabiting India and Ceylon. Four days later a small lizard was put in the cage, and the owner, Mr. Henry, noticed that the infants protruded their tails and wriggled them about in a remarkable manner. It soon became apparent that this wriggling of worm-like tails took place only after a lizard had been placed in the cage and was obviously an effort of the small snakes to attract the lizard. On more than one occasion Mr. Henry saw a lizard actually seize a tail and receive a fatal wound from its possessor. The mother snake never resorted to this means of tricking a dinner.

The hump-nosed viper is not the only snake that has been seen to allure animals with its tail; it seems to be a habit of species whose young have brightly colored tails such as the fer-de-lance of tropical America and our own copperhead. A 15-inch fer-de-lance cut open by Mr. H. W. Parker, the herpetologist of the British Museum, contained a centipede 5.5 inches long. Snakes of this dangerous species are known to feed on vertebrates but this particular infant had apparently taken a chance on the first thing that had been attracted by its "fishing." It is more likely, though, that young fer-de-lances normally have less restricted appetites than adults; our knowledge, rather than the taste of that unfortunate young snake, is probably at fault.

In the chapter on hunting snakes I have told how docile pythons usually are even when found in a wild state. In spite of this, these giant snakes easily overpower and swallow formidable animals such as leopards, wild pigs of various kinds, and huge lizards. Man is only another mammal and, deprived of weapons, not a very dangerous one at that. Being elongate in form, almost hairless, and devoid of hoofs, horns, and other hard external parts, a man should be a particularly palatable object in a snake's eyes. Why, then, is he not regularly eaten by pythons and anacondas?

There are several answers to this question. First, adult human beings of large size are too big for all but the most enormous snakes to swallow and possibly even too large for these. Records and dissections of stomachs show that the giant serpents swallow large prey head first and undoubtedly the shoulders of an adult would be very hard to stretch over. Man's erect posture and his almost universal habit of wearing clothes and hats and carrying various objects combine to make him look even larger than he is. Second, our intelligence, general activity and alertness, and habit of carrying weapons not only render us relatively safe but make us the aggressors. Third, man is gregarious, commonly living and traveling in numbers, sleeping in protected towns or villages, and working together at least in small groups. Fourth, young, weak, or sick persons are commonly watched by parents or guarded by relatives and friends. In spite of all this snakes occasionally devour humans.

Kopstein tells how a fourteen-year-old boy disappeared in one of the islands of the East Indies. A search party was sent out and a large reticulate python found near where the boy had last been seen. It was obvious that the snake had recently fed and the boy was soon cut out of its stomach. In more detail than this is an account of snakes and humans on Ukerewe, a small island in Lake Victoria, Africa. Here it is believed that death or misfortune may befall not only the slayer of a python but his relatives as well, and consequently pythons are often allowed to attain great dimensions. Arthur Loveridge visited this island and was shown the head of a snake that had killed a woman. He writes:

"The woman had been engaged in washing clothes beside a stream and spreading them out upon the ground nearby. She was not very well at the time having, only eight days previously, given birth to a baby which had died. A native coming to the ford observed the clothes spread about but no sign of the owner; he called but received no reply. Thinking this strange he began a search in the vicinity and came upon the woman lying dead in the coils of a huge python. Returning to the village he summoned the men who, overcoming their usual reluctance, killed the reptile with four spear thrusts and two knifings."

The snake itself was a rock python only 14.4 feet long. The men told Loveridge that thirty years before a boy had been killed by a snake; they knew of only the two cases of death but said that others had escaped after being seized.

7

MORE ABOUT FEEDING

Many years ago a reticulate python in Hagenbeck's famous animal park almost swallowed a 71-pound chamois a few days after devouring two goats, one weighing 28, the other 39 pounds. The flash made by a photographer in taking a picture caused the snake to throw up the nearly engulfed chamois and thus spoil a record. Except for the flash it would have consumed 138 pounds of meat within nine days. In this same park a python 25 feet long swallowed a 67-pound roebuck three days after getting down a 17-pound swan. The largest animal that one of Hagenbeck's snakes ever got outside of weighed 84 pounds. It was a goat.

Now all this sounds far away and long ago but actually any one of us can easily watch a snake perform a feat about as surprising if not so spectacular. Only a few days ago in my backyard a 3-foot common water snake weighing 11.25 ounces swallowed a 3-ounce bull frog in 15.5 minutes (see the illustrations facing page 33). This is the equivalent of a 220-pound python (the probable weight of the 25-foot snake in Hagenbeck's park) devouring a goat weighing 60 pounds, or a heavyweight prize-fighter consuming 55 pounds of meat at one sitting.

This swallowing of large objects by snakes is something so amazing that there is no lack of accounts of similar feats from all over the tropical world. The most amusing one is related by Flower: A python killed in the palace grounds of Siam was found to contain a royal Siamese cat, bell and all! This remarkable ability of snakes at once brings up a whole series of questions—the whys and the hows—and these I shall try to answer.

Tens of millions of years ago, when the lizard-like ancestors of modern snakes began to lose their legs, they faced some grave problems. Without legs how can an animal get about fast enough to catch its food;

after securing the food how can it be held and swallowed? In the chapter on locomotion I shall explain how snakes tackled the getting-about problem so we can begin here with the holding difficulty.

Take a lively but harmless snake about a foot long and let it bite your finger. You will be surprised, first, to notice how little the bite hurts and then to feel what a firm grip the snake gets. When you try to pull it off, its numerous teeth only sink deeper. This is because they are set and shaped so that their tips slope backward and the more you pull away, the better they grip. The only easy way to get your finger out is to push forward first one jaw and then the other, and you will see that when you do this the teeth lose their hold.

After you have removed the snake, notice that there are two rows of punctures made by the lower jaw and four made by the upper. Here you will realize more fully than ever how the snake holds on without legs or arms. Of course, if you do not like the plan of letting the snake bite your finger you can doubtless think up some good substitute, any soft object, or even—with permission—the finger of a friend bolder than you. I have been bitten hundreds of times by harmless species without ever suffering bad effects. I feel sure that the painlessness of such bites often enables the snake to secure a firm hold before the victim is stimulated to make violent efforts to escape. The grasp of a snake is in strong contrast to the painful bite of a mammal.

Many snakes even today employ the most primitive method of feeding used by land vertebrates. This method is to seize with the jaws an animal small and weak enough to be swallowed whole and then proceed to engulf it alive. For millions of years reptiles and amphibians ate most of their animal food in this simple way. No special methods of attack or tricks of the trade were necessary but only a certain amount of agility and co-ordination and a good set of teeth. Snakes, with their tendency to swallow large prey, soon found that such a primitive method had its limits and proceeded to develop three new ways of securing a dinner: overpowering by sheer weight, subduing or killing by constriction, and injuring by injection of poisonous saliva.

The first of these three is used by numerous species today, among them our whip snakes and racers. After the victim is seized the body of the snake is coiled over and about it but not neatly around it as in the second method. Swallowing is begun when the animal has been sufficiently quieted to submit to it.

Constriction is used extensively by the boas and pythons. A leopard measuring 4 feet 2 inches from stem to stern was taken from the stomach of an Indian python itself only 18 feet long, and in the struggle that must have taken place the snake had received only seven minor claw cuts. Any limbless animal no larger than an 18-foot snake that can so effectively overpower a leopard certainly has a method of fighting to be envied.

Constriction itself is not so simple. The popular belief is that a snake exerts such terrific pressure that any animal in its grip is immediately reduced to a lifeless pulp with many of its bones broken. This belief is entirely wrong, for no such powerful pressure can be exerted by a snake. Death may come quickly even though bones are not broken and the victim is not mashed out of shape. McLees has advanced a theory that death results chiefly from a general interference of heart action. He wrapped a pine snake around his forearm and found that it squeezed a little tighter every time he contracted his arm muscles in imitation of the heart beat of a victim. The struggles of a very lively animal would of course stimulate the snake even more than the beating of the heart. Obviously the snake's tightening coils would prevent the expansion of the chest after each exhalation from the lungs and the resulting suffocation as well as general nervous shock would help to bring about quick death.

The above statements apply to killing of mammals by constriction. Cold-blooded animals are not easily killed in this way. When a king snake coils about another snake the squeezing of the former seems to do little more than subdue the struggles of the latter and make it take its bitter medicine stoically. Millard tells how a python got its head and neck in its own coils while constricting a large lizard and almost committed suicide. The fact that this python finally succeeded in overcoming the monitor proves that a snake can still squeeze while being squeezed and bears out the above contention that snakes do not readily succumb to constriction. In order to coil around a victim a constrictor must first secure a firm grip on it. A python seizes and wraps itself about an animal in two or three seconds, a surprisingly brief interval of time.

Photographs of ten or more keepers stretching a python out while a string of rabbits is being poked down its throat give an exaggerated idea of its power. The shape of a snake compared to that of a man makes the use of so many men necessary. A champion heavyweight wrestler is doubtless as strong as a python of equal weight yet the wrestler could no more stretch the snake out than the snake could force the wrestler's shoulders to the mat. Any rules that could be devised for such a match would be as funny as the "no hair pulling" agreement that I once heard called for by a wrestler whose head was shaved as bare and as shiny as a billiard ball.

So much for constriction, the most characteristic method used by snakes in subduing prey. Now we come to injection of poisonous saliva or venom, the method de luxe—one that I am sure the great constrictors would deride as arm-chair killing. Between injection and constriction there is all the difference that exists between shooting and overpowering with bare hands. The rattlesnake may achieve safely with one jab as much as the python can accomplish with much effort and risk of injury. Careful studies have proved that the injection method was developed by slow degrees; many fangless snakes quite harmless to man can poison the small creatures that they eat. This subject is so involved that a whole chapter will be devoted to it. It is mentioned here only to be contrasted to constriction.

All of us are taught at the earliest possible moment to "chew your food well," and before we can understand such instructions our food is chewed for us by knives and forks. A baby snake is taught nothing but knows that its food never needs to be chewed. "Swallow it whole" would be its slogan. Snakes have carried this swallowing of large objects so far that they sometimes have difficulty in eating a very small animal. Brimley tells of a common water snake that had to swallow a little frog three times before it would stay down! The persistent amphibian simply turned and hopped out as soon as it had passed the snake's teeth.

I have already told how the rearward slope of the teeth enables a snake to keep a firm grasp even though it has no limbs and even when it does not throw its body over and around the victim. Its next action is to shift the upper and lower jaws of first one side and then the other forward. These alternating movements have been described as the "walking action" of the jaws, and here again the backward slope of the teeth helps; as the jaws are being advanced the teeth do not catch in the prey. The snake is actually pulling itself over the food just as you get a pillow case on by pulling it first here and then there.

The tongue plays no part but is kept out of sight in its sheath in the floor of the mouth and throat. When the victim is relatively large the whole process is slow and laborious and each jaw may be shifted forward independently of the others with plenty of time for rest between movements. The head loses all resemblance to a head, the lower jaws become widely separated where they ordinarily join in front and, at their hind ends, they are stretched far from the corresponding ends of the upper jaws. The skin of the neck and back of the head stretches until the rows of scales stand widely separated. One begins to wonder whether the snake or its prey is the more uncomfortable and if the snake will ever be the same again. As soon as the snake has pulled itself far enough over its meal the muscles of the neck and body are brought into play and the lump is forced down to the stomach by successive sidewise bendings of these parts. The head promptly resumes its proper shape and the snake may even look around for more.

The time taken to perform a feat of swallowing varies very widely, depending as it does on the size and shape of the object tackled. I have already stated that my 11.25-ounce common water snake put a 3-ounce bull frog away in 15.5 minutes. While it was busy doing this, a 6.5-ounce common garter snake swallowed two frogs, together weighing .75 ounces, in 1.25 minutes (see illustration facing page 33). The smaller garter snake at his rate could have devoured 3 ounces of frogs in only 9 minutes. This would indicate that a snake eats more efficiently when it takes animals of moderate rather than of very large dimensions. My time records are nothing compared to those of observers who have reported swallowings lasting as much as five hours.

Conant tested his water moccasin and found that it could eat in a little less than two hours a large bull frog measuring with outstretched legs just over 12 inches. The snake was only 2 feet 9.5 inches long and the diameter of its head 1.25 inches. The frog measured 2.75 inches across the body. That this moccasin had done even better than its best is shown by the fact that when time for the next meal arrived it refused to molest a slightly larger bull frog but quickly devoured a small leopard frog.

On the other hand a snake walks its jaws along another snake of its own diameter so rapidly that the victim seems to vanish as if by magic. Angel states that a 10-foot rock python ate another snake of its own species about 7 feet long in less than 10 minutes. Shape seems to be quite as important as size. The question of time is of special interest because a snake is defenseless while eating and consequently open to attack from any lurking enemy or passing human being.

If a meal refuses to be dragged and forced down in a comparatively short time a snake must stop at regular intervals to breathe. This is done by pushing the glottis or anterior end of the windpipe out between the object being eaten and the floor of the mouth. After a spell of breathing the glottis disappears and swallowing is resumed. Cartilaginous rings in the walls of the glottis make it stiff enough to be pushed forward in this manner.

Snakes surprised while eating often throw up the food and dash away. If the swallowing process had been very slow and the victim nearly devoured it would be wet with saliva. Vomited animals in this condition have led to a belief that snakes cover their prey with saliva before beginning to swallow.

What happens to these large masses of food that a snake gets down and what sort of an apparatus handles them?

A snake is a vertebrate animal. All vertebrates are built on essentially the same plan so it will not surprise you when you look inside a snake to find about the same organs that you would find in a fish, or dog, or a man. The shape of a snake has apparently brought about the most noticeable changes; it has kept the paired organs from lying exactly opposite one another. The advantage of such an asymmetrical arrangement is obvious.

Although the relative lengths of the different parts of the alimentary canal vary even from one individual of the same species to another, the following table based on a specimen of the common water snake of Europe will give you some idea of what to expect in a snake:

Mouth	.75	inch
Œsophagus	11.75	inches
Stomach	3.50	"
Small Intestine	28.75	"
Large Intestine with Cloaca	6.25	"
Total	51.00	"

The specimen itself measured 31.5 inches from snout to anus. You see at a glance that a snake's intestine does not have to coil all about the way yours does. In man the small intestine alone is several times as long as his body. A little coiling in a long body suffices for an ophidian. The 3.5-inch stomach of this snake by no means kept it from eating objects much longer than that; when the stomach is too small the œsophagus serves as a temporary reservoir.

In all the groups of vertebrate animals except the mammals there is a terminal sack or receptacle into which the waste products from the kidneys and intestines empty and through which the reproductive fluids of the male and the eggs or young of the female must pass, and this sack is called the cloaca. The anus is the exit from the cloaca to the exterior. The body and tail of a snake fit together so smoothly that one must look carefully to find the anus which is neatly covered by a scale. Everything beyond the anus is tail.

Dr. Francis G. Benedict has written a most fascinating though technical book called *The Physiology of Large Reptiles* and in it he tells many surprising facts about the digestion of snakes. Among other things he shows that the temperature of a snake not digesting a meal or incubating eggs is slightly below that of its environment. In fact this is what we mean when we say that reptiles are cold-blooded; they do not keep their temperature at a constant point as we do. If you want to find out whether a snake has fever you have to take the temperature of the room as well as of the snake. When you give a snake a big meal his temperature goes up a little, while he is actively digesting.

The determination of the exact figures for the temperature of the environment of a python is astonishingly difficult and the results complicated and variable; the essential thing to remember is that a snake is about as cool or warm as his surroundings. A mammal such as the Arctic fox can keep its temperature 140° Fahrenheit above that of its environment!

It is a general rule in chemistry that the rate of any reaction or chemical change varies with temperature. From this it is easy to guess that you could not fix the rate of digestion by a snake without first naming a degree of temperature. Benedict found this to be the case; digestion was much more rapid above 30° F. than below that point. The size of the meal must also be taken into consideration. With so many factors involved the matter becomes complex before we are well into it. In fourteen out of twenty-two successful experiments, however, the peak of digestion was reached in 22 to 50 hours after eating. The total time of digestion is not easily measured but may be put as five or six days on the average. This is to be compared with 12 hours total in man, 24 in dogs, and 36–48 in ruminants or cud-chewers.

It is clear that a snake digests more slowly than many other animals. Even when it takes small meals it cannot assimilate them in a short period of time. There is an entirely different angle from which to view this matter. What can a snake accomplish in eating a meal? The energy value of a 20-pound pig may be put at 44,000 calories, and the daily needs of a 70-pound python kept in a temperature of 86° F. are 106 calories. From these data it is easy to calculate that a 20-pound pig eaten by a 70-pound python may give four hundred times the number of calories needed by the snake for one day. A man digests a meal many times faster but after all he needs more food almost immediately whereas a snake really accomplishes lasting results in swallowing its prey.

Some Eskimos are known to consume at a meal meat equal to 5 percent of their weight and in doing this they come nearer to competing with snakes than any other human beings. As well as being able to eat large amounts of food at a time, snakes can store great quantities of reserve material and thus be prepared for long fasts. In this ability they surpass all warm-blooded animals. Benedict aptly remarks: "With no other animals in the world, certainly among the vertebrates, can one expect such economy in the taking of food."

In spite of the fact that a good meal will last a long time snakes often eat frequently. Kopstein fed 230 young and nestling rats to a Sumatran cobra in 124 days. The snake was nearly seven feet long and ate a meal about every third day. A cobra living in the tropics like this one would of course need no reserve supply to carry it over a long period of hibernation. This same snake doubtless could have survived those 124 days without being fed at all or would have been kept in good condition by eating one young rat a week. Reports of long fasts by snakes are easy to find. Vaillant tells of a rock python that lived two years and nine months without eating and then ate and survived over three years more on only four meals. Records of fasts of a year more or less are numerous.

Like man, snakes have two main channels through which to get rid of the waste products of digestion: the intestines and the kidneys. The intestines function in the ordinary way; they dump the feces into the cloaca, which in turn passes them out through the anus. Digestion is so complete that only the tougher parts of the devoured animals are not affected. Hair, quills, feathers, claws, pads of the feet, fangs, and similar structures are to be found in the excrement. Bones are completely destroyed by the powerful digestive fluids.

In man the kidneys degrade their nitrogenous waste products to urea, which is highly soluble and readily carried out in our liquid urine. In contrast to this the kidneys of a snake secrete their waste products chiefly as uric acid, a highly insoluble substance. This uric acid is then washed down by a rather weak stream of water through the ureters direct to the cloaca, for there is no special reservoir such as our urinary bladder in which it can be stored.

In the cloaca this product of the kidneys of course comes in contact with the feces from the intestines. The former is white and chalk-like; the latter dark and sometimes not unlike the dung of a dog in appearance. They may be distinguished not only by color but by composition, the white solid urine being quite homogeneous whereas the other probably will contain bits of undigested parts of the original animal. The cloaca generally holds some liquid along with the whitish urine and the dark excrement from the intestines. It is impossible to say just how much of this liquid originates in the kidneys and how much in the intestines.

A snake follows no such rule as "a regular daily movement of the bowels." Usually feces are passed from two to ten days after eating. Steinheil's record of the behavior of a 5-foot example of the lizard snake found in the Mediterranean region represents the normal proceedings for a snake of medium size. On July 10 it ate a small rabbit and passed much excrement on July 12 and 15, a little on the thirteenth. A guinea-pig consumed July 17 caused large evacuations on July 19 and 21. Two rats were swallowed July 23 and good movements noted the second, fourth, and sixth days thereafter. This indicates that two or three movements are required to get rid of one large meal.

8

REPRODUCTION

It is astonishing how little we know about reproduction in reptiles. One can find hundreds of descriptions of every detail of bird life, and of course domestic mammals have been studied for centuries. Fish breeding is a special branch of economic science. Frogs more often than not call attention to their love-making by shrill notes.

Among reptiles the snakes have been especially successful in hiding their sex life from the eyes of man and one has to search far and wide to find a good description of snake courtship and mating. Even herpetologists have been heard to say that snakes have no interesting or complicated habits—they are born, they grow, they reproduce, and they die —that is all. How monotonous!

There are in existence today some twenty thousand relatively technical books and papers on snakes, and by diligent search through many thousands of these one can bring together a patchwork account of reproduction in snakes. It would of course be much better to use a few monographs describing the complete life histories of several interesting and typical snakes but, alas! such works are not to be found.

Tennyson wrote: "In the spring a young man's fancy lightly turns to thoughts of love," and he might even more truthfully have written "snake" instead of "man." Apparently a snake awaking from hibernation first thinks of a mate. Nature takes no chances but sees to it that the most important things are attended to without delay. Since development of the young requires many weeks it is necessary for them to be started along as soon as possible. They have to be hatched or born long enough in advance of cold weather to feed and gain a little strength before facing their first winter. The almost universal rule for snakes of temperate climates is one brood a year with mating in the spring.

Eggs are laid in early summer and the young appear during the middle or late summer.

In the chapters on feeding habits I have explained why snakes at the end of hibernation should still be in good physical condition and, therefore, strong enough to mate perhaps even before eating.

In order to breed, the males and females not only must be able to recognize members of their own kind but, at least in the case of the males, tell the sex of the individuals recognized. You can best appreciate their difficulty by trying to identify the kinds and sex of snakes yourself without counting spots, stripes, or scales or examining the base of the tails. In spite of a superior brain you will find this anything but easy.

Just how snakes succeed so well is by no means fully understood, but Noble and Clausen devised a series of clever experiments proving that DeKay's snakes recognize each other chiefly by smelling an unknown substance given off by the skin. Sight is depended on much less than smell and, strange as it may seem, color plays no part. A male tells a female by her odor. The fact that males repeatedly have been found mating with dead females shows how much a snake relies on his senses rather than his "sense" or what we like to call intelligence.

In a few species the male and female are colored differently. Do these, in contrast to DeKay's snake, use color in choosing mates? No one knows; this whole fascinating problem of sex recognition has just begun to be solved.

After a male has found a female his next duty is to implant in her body countless microscopic cells or sperm. Since the survival of most animals depends entirely on the completion of this one link in the chain of life, Nature has taken no chances but worked out thousands of ways to insure proper sexual union. Even when, as among fishes, the female merely has to expel eggs into water, Nature must be sure that a male is attracted to the spot to discharge his sperm among the eggs.

The whole outward form of many animals, especially birds, is determined by this sexual necessity. Brilliant plumages or fur patterns may serve to attract the opposite sex. Furthermore, elaborate courtship dances and displays also play an important part. Nature made sex impulses strong to insure the survival of the species. A sexless world is conceivable but it would be a very different world.

But let us get back to our snakes. One of the simpler methods of courtship among them is for the male to slide forward along the back of a female rubbing his chin against her back. This is done by our garter and water snakes. The males of at least some of these kinds have sensitive tubercles or numerous minute structures on their chins which, when rubbed against a female, seem to arouse the males themselves to a desire to mate. At least Dr. Noble found that covering these bumps with adhesive tape kept the males from mating. Many male garter or water snakes may gather over one female, all trying to rub their chins on her at once. The female remains quite passive and the males never fight among themselves but each tries to effect union with the female.

A courtship complicated enough to be called a dance is practiced by the European Asclepius snake. Stemmler-Morath describes it about as follows. At first the male crawls slowly after the female, his tongue darting in and out against her. As she increases her speed little by little, the male keeps pace with her. This goes on and on until the two snakes, instead of crawling, are dashing wildly through field, over bowlder, up into bush and down again, like creatures gone mad. Finally the male, overtaking his mate, wraps his neck about her with the speed of lightning and draws himself up along her body. The dance continues, the two bodies close together, first one then the other on top, their heads held the same distance from the ground. After many minutes of this one of the pair suddenly rears, freeing its forward third. The other immediately follows suit and the snakes pose thus, their anterior thirds raised with heads close together, only the hinder thirds still intertwined. After this they may continue to move about for some time, preserving the same general figure in spite of their motion. The entire dance often lasts more than an hour and precedes the actual union which generally takes place with the couple hidden in grass, under a bowlder, or beneath a fallen tree.

This performance of the Asclepius snake is interesting because of the activity shown by the female. The female dhaman of Asia also takes a lively part; courting pairs of dhamans have been seen "sparring at each other like two young cockerels" while their posterior thirds remained intertwined.

Little is known about love-making among the giant snakes, but male anacondas and boa constrictors are known to scratch the females with their tiny spurs or vestigial legs before mating. This scratching sometimes can be heard several feet away. Mother Nature again proves her ability to make use of a structure that no longer serves its original purpose.

Males of the common viper of Europe and central Asia have been observed to go through an elaborate dance near a wholly passive female. It seems, then, that there are many types of courtship among snakes. Some day we may even be able to classify them by the way they make love. Such has already been attempted with lizards and not without a degree of success.

Until quite recently it was assumed that one mating produced a single brood, all the embryos developing at one time. A female was said to breed once a year. Tropical snakes have been and still are studied so little that some herpetologists have long stood ready for surprises such as the one sent from tropical Africa only a few years ago. Stanley Woodward of the Gold Coast Colony had a captive night adder that laid a cluster of eggs every month from April through October and this in spite of the fact that she was kept entirely alone. Young hatched from all eggs of the first two and most of those of the third and fourth clusters. These facts probably mean that a female of this species is able to retain for at least five months living sperm or male reproductive cells in her body, where they serve to fertilize successive batches of developing eggs.

The males of both snakes and lizards have paired sexual organs that are kept in the base of the tail instead of in the body itself. Each one of these is called a hemipenis and is used only for reproduction, having no connection with voiding of urine. During a single act of mating only one hemipenis is used, the two being quite separate from each other. The structure of these organs varies a great deal from species to species but most of them are beset with numerous sharp spines. This necessitates their being turned inside out while being inserted or withdrawn; if they were not the female might be badly torn.

The unique action of a hemipenis is not easily explained, but if you attach a thread to the tip of a finger of a glove on the inside and then pull the finger into the palm cavity of the glove by means of the thread, you illustrate the return of an everted hemipenis into the base of the tail. In the snake a long muscle attached near the end of the tail corresponds to your thread. The fluid containing the sperm flows along a deep groove on the extruded hemipenis.

The hemipenis is often protruded by an individual suffering great pain, and hence the cruel practice of burning a snake to prove that it has "legs." A simple and humane way of viewing these organs is to push them out by pressing along the lower side of the tail toward the anus. They are not always easy to force out, however.

It is generally assumed that, after mating, males and females separate to live, until birth or laying time arrives, just as though mating had not occurred. A few facts are being brought to light proving the error of this assumption. Dr. Clausen found that female DeKay's snakes with young not only isolate themselves but remain concealed and inactive until their broods are born. There is some indication that the females of certain other species, the copperhead for example, congregate in convenient hiding places until they give birth to their young. A few species undoubtedly remain together as mates at least long enough to see the young safely into the world. I shall say more about this pairing later.

Although the majority of snakes lay eggs, not a few give birth to living young. In China only eleven species among sixty-one whose breeding habits are known produce their young alive. Live-bearing species are relatively more numerous in the United States where there are roughly two of them for every three egg-layers. The boas, water and garter snakes, water moccasin, copperhead, and rattlesnakes are the important kinds in this country that bear their young alive; the whip snakes and racers, rat snakes and other Elaphes, hog-nosed, ring-necked, indigo, king, bull, pine, and coral snakes lay eggs. A little more information on this subject is given in the chapter on classification.

Let us first take up the snakes that produce their young alive. Strange as it may seem, the exact time that elapses between mating and birth of young has been accurately determined in few kinds. For Russell's viper it is said to be more than six months, for the common viper of Europe and central Asia four and a half, for the green pit-viper of the East Indies at least five, and for Butler's garter snake three and a half to nearly five. An exact determination for DeKay's snake was recently made by Dr. Clausen. In eight females from Long Island the period varied from 105 to 113 days.

The actual process of birth in snakes is relatively simple. In fact, if human beings were like snakes there would be no maternity hospitals, doctors to attend births, or baby nurses. As shown in illustration facing page 76, the young are born enclosed in a delicate transparent membrane from which they soon escape, in some cases immediately, in others after minutes or even hours. The mother is generally restless before the young are extruded but relatively quiet during the birth process. When a fœtus is ready to come out, the female's tail is elevated. In the case of a copperhead watched by Gloyd, actual extrusion of each offspring took about ten minutes. One young has been observed to follow another after only a few seconds but more often the mother rests for some time after bringing forth each little snake, the birth of a whole brood requiring from a few to many hours.

It is doubtful that she suffers much as we think of suffering. Some years ago Frank Speck offered earthworms to a Butler's garter snake which had just given birth to four young. She ate two worms and ten minutes later produced another little snake.

Within a few days, sometimes almost immediately, the young shed their skins. Parent snakes do not care for their young so the "little dears" must fend for themselves as best they can. Newly born snakes have been observed to eat within ten minutes after their arrival.

Matters are quite different among the egg-laying snakes, for in these the female must deposit her eggs in a suitable place. All snake eggs are concealed when laid, and none of them therefore have protectively colored shells like the eggs of many birds. Snake eggshells, moreover, are not brittle but flexible, elastic, and tough. With a few exceptions they are white or nearly white at first. Although most of them are noticeably elongate they vary greatly in proportions. Compare the several illustrations showing eggs of various species. I have never seen or heard of a spherical one, however.

The shell itself is beautifully constructed. In the pine snake, for example, it is made up of nine or ten layers of long, scarcely branched, hollow, elastic fibers, each fiber approximately $\frac{1}{350}$ of a millimeter in thickness. These layers are essentially alike, the individual fibers in each lying parallel one to another but always following a wavy course. They are not intertwined. The fibers of the first layer extend obliquely around the egg, whereas those of the next one also lie obliquely but in the other direction, that is, at right angles to the fibers of the first layer. This puts the fibers of every alternate layer parallel. A thin incrustation of calcium carbonate crystals and granules gives the egg its rough surface. The calcium carbonate impregnates only the outermost fibrous layers.

This marvelously constructed shell is deposited on the egg during its passage down one of a pair of long tubes called oviducts in the body of the snake. Minute processes turn the egg first one way and then the other, allowing the cells of the oviduct walls to wrap it up in successive layers of the microscopic threads. What man-made machine could perform such a complicated and delicate task!

Of course a mother snake takes no conscious part in the development of her eggs or the making of the shell inside her body, but matters change when laying time approaches. She must now "get busy" and find a place to deposit her clutch. This place must be suitable in respect to temperature and humidity, neither too warm nor too cool, too dry nor too damp. As wonderfully constructed as the egg may be, its shell is not able to keep heat in or entirely control the passage of water vapor.

With regard to temperature there are four possibilities: The eggs may be laid in material that stays warm enough to insure development, placed where the heat of the sun reaches them indirectly, deposited in decaying vegetable matter to be warmed by heat of decomposition, or they may be incubated by the mother. The higher the temperature the more rapid the development and, in temperate climates, the better chance the young will have to feed and grow before the arrival of winter.

The nesting sites chosen vary enough to defy generalizations. (Compare illustrations facing pages 72 and 73.) As a rule, the female searches about until she finds a natural cavity or hole in suitable material. It may be in leaf mold, a mass of decaying vegetation or wood, or in a manure heap, under a stone or pile of old lumber. A deserted animal burrow or a hole under a log or rock wall is often chosen. Should the cavity be too small she enlarges it by crawling and pushing about in it.

If no satisfying place is found she may even make one. For example, more than forty years ago, about the middle of May, Mr. Peter Hoff watched a pine snake crawl a hundred yards across a New Jersey squash and cucumber field pausing frequently to test with her snout the resistance of the loose sandy soil. After much effort a spot by a row of plants was selected and excavation begun. The soil was loosened and pushed out with the head, the tail being used to brush it away. A hole large enough to conceal the entire snake was finally constructed and into it the expectant mother retired to deposit her eggs.

Two unusual specializations in nesting are interesting. The first is the habit of many females of a species laying in one site at about the same time. Hundreds of eggs of the common water snake of Europe are sometimes found together and even as many as 3000 have been reported. (See illustration facing page 72.) The second is the laying of eggs in termite or "white ant" nests. In open country on the island of Java Dr. Kopstein found a termite nest eight inches in diameter hanging ten feet above the ground from a bare tree. He took it home where it remained unnoticed until, more than three months later, he was astonished to see a young snake of a rare species coiled upon it. Within a few minutes another appeared there, then another and another, until in all he had five hatchlings. On opening the nest he found six fresh empty eggshells in it, one snakeling having made good his escape. The nest was perfect except where the snakes had emerged.

Kopstein and others have now secured further evidence that certain snakes and lizards habitually lay their eggs in such nests. How snakes get them in is still a mystery. Does the parent penetrate the nest by force, does it find one being built, or does it choose a damaged one? Also what is the good of laying in such a place? Probably the eggs gain protection as well as more uniform conditions of temperature and humidity.

The actual process of laying has been accurately observed and described in few species. (See illustration facing page 76.) Dr. Blanchard has given a detailed account for the eastern ring-necked snake. In this species the female lies coiled and deposits the eggs within her coils. The forward part of the tail is raised as an egg reaches the anus. The egg is forced out of the cloaca in about five minutes, and normally intervals of twenty-five to fifty minutes elapse between depositions. The eggs of one clutch are more or less stuck together but this depends on chance contact before the surface has thoroughly dried. Eggs adhering in a mass must have been laid at fairly short intervals. However, Gloyd describes those of the striped racer in Texas as "non-adherent." A clutch of twelve freshly deposited eggs of this species was found by him to weigh three-fourths as much as the mother after laying. She must have felt as though she had really done something!

The period of incubation in snakes varies from a few days to three or even four months, depending not only for any one species on the stage of development of the embryo at laying but on the temperature at which each clutch is kept.

Heat speeds up development. For instance, Blanchard found that eggs of the eastern ring-necked snake kept under "ordinary laboratory conditions" in Michigan hatched in an average of 56 days whereas those kept in a lower temperature required some 84 days. The shortest incubation period recorded by him for this species was 46, the longest 87 days.

In the smooth-scaled green snake this period is still more variable, the extremes for it being 4 and 23 days! This species may occasionally produce living young. Obviously, then, it is impossible to give an average incubation period for snakes in general or to name a normal one for any particular species. As Blanchard and others have shown, too much depends on the season and weather, the nesting material and site, and the latitude and altitude of the region where the eggs are laid.

Now we have arrived at the most interesting subject of all, care of eggs by parent snakes. Here snakes show not only variation in behavior from species to species but between individuals of the same species. For example, two females of the common water snake of Europe laid eggs in the same English garden. One guarded her clutch diligently for thirteen days (until she shed her skin) but the other deserted hers immediately.

It is not surprising then that we find conflicting accounts of the same species. It is something like keeping a score. We begin by assuming that a species pays no attention to its eggs until someone makes a report to the contrary. The snakes are doing fairly well; every year, as our knowledge increases, we learn of more species that take at least a little interest in their eggs. This interest varies from merely staying at the site of deposition for a brief time to incubating the eggs by remaining closely coiled about them until hatchlings appear. Another variation is actively guarding rather than incubating the eggs and I shall soon show that even the male may take part in this.

On August 31 a water snake was brought to me in southern China with a batch of ten eggs which obviously belonged to her for she lay coiled about them without attempting to escape or objecting to being touched. Snakes of her kind are ordinarily active and difficult to approach; when captured they fight viciously.

Similar passive behavior has been seen in other species and can hardly be called guarding even though the mere presence of a snake might frighten away certain enemies bent on eating eggs. It is possible that in such cases the female is actually incubating the eggs. Since snakes normally are little or no warmer than their surroundings a female in order to incubate must either get a "fever" or carry heat to her nest by alternately sunning herself and coiling about her eggs. Brooding individuals of small species have not been carefully studied but incubating pythons have attracted the attention of scientists for more than a hundred years and been the subject of very detailed investigations.

The most thorough of these was made by Dr. Benedict on an African rock python that laid about twenty eggs in the National Zoological Park, Washington, on April 5, 1931. During incubation this snake was found to be about 6° Fahrenheit warmer than its environment. Even in pythons this question is not so simple, a recent study of a five-and-a-half foot Sumatran blood python having shown that her temperature was not increased while she brooded a batch of sixteen eggs. Above all a student of science must keep an open mind.

In the same Chinese place where the passive water snake and her eggs were brought to me a tea picker discovered on August 12 a chunky but courageous little pit-viper on her nest in a pile of decaying bamboo fiber just as shown in illustration facing page 73. In contrast to the mild-mannered water snake, this pit-viper defended her six eggs valiantly and remained with them for several days after their discovery. In fact she allowed me to expose the nest completely and take several pictures. Only when I had removed the eggs did she give up and attempt to escape. Like other snake nests, this one was little more than a bare cavity evidently enlarged by the parent. The fortunate tea picker was so pleased with his reward of fifty cents that he deserted the tea fields to search for more pit-viper nests.

Nest guarding of this active kind has been described often and must certainly have great value. Few animals would like to tackle a poisonous snake in such confined quarters, and even a harmless species would be difficult to overcome in its nest. Small mammals such as rats have been known to make serious inroads on the snake population of local areas by eating their eggs. A strongly developed egg-guarding habit might have saved these snakes. In India brooding king cobras have even caused paths to be temporarily closed.

In the vast majority of cases only the female attends the eggs but the male may also take part. Some years ago in Pennsylvania, Oliver P. Medsger noticed during July unusual behavior on the part of two pilot black snakes. These reptiles would alternately lie on the surface of a pile of sawdust and bury themselves in it. When removed to a distance they always returned. After three weeks of observation, Dr. Medsger dug into the pile and found the male coiled around forty-four eggs. As suggested by their discoverer, it is quite possible that the snakes were carrying heat to the eggs by first sunning and then coiling about them.

The male king cobra is said to remain near by while the female enfolds the eggs which are laid in a pile of leaves or vegetable rubbish. Perhaps the clearest case of combined guarding of a nest was observed a few years ago in the Belle Vue Zoological Gardens, Manchester, England. In this zoo a pair of cobras burrowed into the bottom of their cage where the female laid about eighteen eggs. During incubation, which lasted from March 8 to May 12, the pair diligently tended their nest, the male always remaining near and "taking the place of the female during the three hours that she left the eggs to drink and feed." Both parents were unusually vicious while in possession of the eggs.

When hatching time arrives the egg of any animal changes suddenly from an incubator into a tomb, and the tougher the shell the tighter the tomb; Mother Nature must promptly turn a tender embryo or larva into a jail-breaker. This cleverest of mothers has solved the problem over and over again by developing a great variety of shell-breaking devices. In some amphibians a hole is dissolved by the secretion from a special little gland on the snout of the prisoner. Sometimes absorption of liquid develops pressure that bursts the shell, and certain insects pierce their way into the world with spikes. The method of the reduvius bug is unique: A tiny membrane fills with gas, lifts the lid off the egg, and explodes, thus blowing out a passageway for the larva. Shades of modern warfare even in the insect world!

Instead of developing a gland or using a bomb, snakes grow a special tooth on the foremost bone of the skull. This "egg-tooth" is plainly visible on embryos of large species and appears to project from the mouth. It is usually prominent enough to be felt even on the smallest hatchlings but must be looked for soon because it is shed within a few days. These shell cutters vary greatly in shape and size; the largest one I have ever seen projected a distance equal to two-thirds the diameter of the eye beyond the tip of the lower jaw. It was on a hatchling from French Indo-China.

Egg-teeth are even present in rattlesnakes, copperheads, and many other live-bearing species, but with them it seems to be a survival of bygone days when they had the egg-laying habit. Nature not only develops such structures slowly but has difficulty in getting rid of them when they are no longer useful.

When the young snake is ready to emerge it makes many slits in the shell with the egg-tooth and then pokes its snout through the area thus weakened. (See illustration facing this page.) It does not crawl out immediately but lingers, thrusting first its snout and then its head in and out many times and always disappears within the shell at the slightest alarm.

There is much variation in the length of time that elapses between the first slit of the egg-tooth and final desertion of the egg. Blanchard watched numerous individuals of the smooth-scaled green and the eastern ring-necked snakes and determined that hatchlings of both these species commonly take from a half to a full day to emerge. One would expect, then, the hatching of an entire clutch of eggs to require two or three days, and such seems to be the case.

When the hatchling first crawls out it is so wet that particles of dirt stick to it, but after moving about for a few minutes the skin becomes clean and dry. The hatchling is now an independent snake ready not only to eat but to take care of itself in every way. One important thing remains to be done, namely, shed the skin in which it entered the world. This occasionally takes place almost immediately, sometimes not for two weeks, but usually within five to ten days of hatching. This and subsequent sloughings depend largely on the humidity of the environment, the process being accomplished most successfully in humid surroundings.

It is a strange fact that, although so many snakes take an interest in their eggs, no species is definitely known to care for its young. This statement of course contradicts the popular story that mother snakes often swallow their offspring upon the approach of danger. I shall discuss this belief in some detail in the chapter on popular beliefs.

The mere discovery of a female snake in company with a lot of hatchlings or recently born individuals does not prove parental care because the young and old might just be lingering in an especially agreeable spot. But as I have already remarked, in studying science one must above all keep an open mind and careful observation of newly arrived broods of snakes and their parents is well worth while. For example, you can jar the cage in which they are kept or frighten them in any other way to see whether they disappear down the mother's throat. Be sure, though, that they are not simply crawling under her.

You will find a good deal of information on size and growth of young snakes in the chapter on age and growth.

Back of all I have been writing on snakes and their offspring lies a story thrilling in every detail but very long drawn out. It began millions of years ago when vertebrate animals were chained to the waters partly because they could not breed on land. The fishes laid eggs that dried up when removed from the water. It was the amphibians that first reached out for solid ground. They left the water all right but had to return to it to breed and pass the first or tadpole stage of existence. They had only begun to sever the chains binding them to a watery existence. Next came the reptiles with eggs that could develop on land. At last the vertebrates had broken the chain and freed themselves from the bondage of water. What a debt of gratitude we owe those grotesque old rascals, the early reptiles! We can live on land and play in the water.

But what about these reptile eggs, how were they able to survive on land? This is a question for the chemical embryologist to answer. These specialists tell us that a growing embryo needs yolk (from which to draw nourishment), water, and certain gases. Therefore, before taking their eggs onto land, reptiles had to discover some way to supply them with water as well as with a shell to prevent the drying up of water, embryo, and yolk. This covering could not, however, be air-tight unless a supply of gas as well as water were put inside it too.

These clever reptiles solved this difficult problem by providing their eggs with: first, a shell just porous enough to allow the passage of gas but which could keep the egg liquids from drying up too readily; second, a special substance, the egg-white, from which the embryo, by means of complicated chemical reactions, can draw a supply of water.

Birds have gone a step further by providing more egg-white, adding a special chamber filled with some of the necessary gas, and developing a hard and more resistant shell that is an efficient protection against drying up in ordinary air. Moreover, the warm-blooded bird is able to rear young in cold climates by sitting on its eggs and thus controlling their temperature. The little incubating that snakes do does not compare to that of birds but is merely a suggestion of the possibilities that birds developed to the fullest extent.

You can easily imagine how much more complicated one of these reptile or bird eggs is than a fish egg lacking both shell and egg-white. Has this improvement cost anything? It has indeed for, as these eggs increased in complexity and size, the numbers produced by one individual were correspondingly reduced. The eggs laid per year by a female of the most fruitful fishes run into millions, by the most productive amphibians into thousands, and by the most prolific reptiles into hundreds only. The tendency all along the upward road from fish to man is to put more effort on each egg or embryo but to produce fewer offspring. A codfish can lay as many eggs in a year as there are people in New York or London!

Among snakes the pythons sometimes lay about one hundred eggs at a time, and several other snakes do not fall far short of this record. Unless certain tropical snakes surpass this mark by depositing many clutches a year, one hundred is probably the maximum number of offspring produced annually by a single snake.

I know that there is a question in your mind and an important one too. What about those snakes that bear living young, where do they enter the picture? The answer is that some of those snakes have actually foreshadowed the highest method of reproduction, the one found in nearly all mammals wherein the unborn young derive nourishment directly from the mother through an organ called the placenta.

Until recently it was thought that live-bearing snakes merely retain the eggs in the body until the embryos have fully developed. The late Hazel Claire Weekes showed, however, that in at least two Australian snakes the young receive nourishment from the mother much as mammals do. How many other snakes have placentæ remains to be discovered, but at least we must give the group as a whole credit for developing independently this highest of all reproductive methods. A few lizards are known to have this same form of development, but it has been found in no other reptiles.

9

LOCOMOTION

IF YOUR arms and legs were cut off, you would be almost entirely helpless. Snakes have neither arms nor true legs and yet they get about very well indeed, most of them being able to crawl, climb, and swim. How can they possibly do so well without limbs?

Put a snake on some loose smooth sand and watch it crawl. First, you will see that every part of its body stays against the ground, that is, it crawls by lateral or sidewise movements and not by up and down ones as many pictures show it doing. Next, notice that all parts of its body follow the same ever-winding track. A crawling snake suggests a stream of water flowing along a winding bed. Finally, you will be surprised to see that the snake leaves behind a series of long, slightly curved piles of sand, one bordering the rear part of each curve, and right here you have the key to the whole problem. (See illustration facing this page.) These piles are nothing more or less than the pivots that have been used by the snake in pushing its body forward. Without something raised to push against, it has great difficulty in crawling.

To test this out, put the snake on a large piece of smooth glass and watch it slip and skid. Now take several small pegs and stick them with glue or cement in a slightly zigzag row. Start the snake so that its head can just reach the first peg and you may see how easy it is for the animal to move across the glass, now that the pegs are there to help it. I say "you may see" because snakes are not such easy animals to experiment with; they have the most annoying way of doing anything but what you want them to do.

After seeing your snake crawl across glass with the help of the pegs you can readily understand how it crawls through grass or bushes, for each stem and bush is just another peg to serve as a pivot. There are almost no really smooth places in the woods and fields, nor, for that matter, anywhere on the natural surface of the earth, and therefore snakes can count on finding a "foothold" for their bellies almost everywhere.

The type of crawling that you have just observed is called the "lateral undulatory movement" by Walter Mosauer, who has carefully studied the locomotion of snakes. It is undoubtedly the chief way that snakes use in getting about. However, if you walk along sandy roads in the coastal plains of the southern states you may find marks in the sand that look as though a large rope had been dragged straight across the road. These marks are the tracks of rattlesnakes and prove that snakes do not always use that "lateral undulatory movement" in traveling about. Unfortunately, the type of movement that makes these straight tracks is not easily observed because it is unusual and used chiefly by thick-bodied species when crawling leisurely. It is called the "caterpillar movement"—an easier name than that of the more important type just described.

To understand the caterpillar movement one must know that a snake's belly is covered by a series of narrow, crosswise folds of skin or overlapping plates. The front part of each of these plates is hidden under the hind edge of the next one in front. The ends of the plates are loosely attached inside the body to the ends of the ribs. The other ends of the ribs are of course fixed to the vertebrae which are exceedingly numerous.

A very complicated system of muscles enables the snake to move the belly plates (shown in Figure 6 of the Appendix) and skin of the lower sides backward and forward a very short distance at one time. If all the plates were moved forward at once the whole snake would of course be carried backward. To avoid this the snake moves a few of its plates forward at a time and so actually crawls. As already stated, the free edges of these plates are the hind edges, and this means that they catch on any and every projection from the ground and keep the scales that have already been carried forward from slipping back. This movement is seen as a wave of the skin beginning under the neck and moving along the belly in a fascinating manner. One wave follows another as the snake slowly progresses.

Like you, a snake has two chief ways of getting over the earth: you run or walk, the snake uses one or the other of the methods described above. Sometimes we say that a man is moving at a gait "between a run and a walk." This is exactly what a snake likes to do—mix up his gaits. Often you will see a snake doing a little of the caterpillar type and undulating at the same time. Its body is so long that one part can be doing one while another part does the other! Occasionally a snake moves by the simple method of repeatedly curving its body like a flat S and straightening it out again. This method scarcely deserves a name.

Although sandy areas give us a fine chance to study a snake's way of moving, they are not easy places for snakes to travel in. Walk in the sand and you will discover why. It gives way, letting your feet slip back, and you consequently lose some distance each step. This is just what happens to the snake. Those little piles of sand that he leaves behind are proof of this—he is forced to pile up a certain amount of sand before it affords a strong support against which to push.

A few desert snakes have side-stepped this difficulty by developing a distinct new type of movement called side-winding. This beautiful movement is too complicated to explain in detail but illustrations following page 76 will give you some idea of it. When a sidewinder rattlesnake travels in this fashion its body is thrown into great loops and seems to be flowing along sidewise; the more one tries to see just what is going on, the more puzzled one becomes.

Most amazing of all is the track that it leaves. Such a track is illustrated following page 76, where you will see that no piles of sand are built up; this means that the snake is not wasting energy by piling sand or losing ground by slipping. It only asks the sand to support the weight of its body, not to resist a horizontal push. The greater and lesser *Cerastes* vipers of Africa and Asia are also good sidewinders. Both of them are found in deserts. These vipers and our sidewinder are excellent illustrations of how animals in different parts of the world solve the same problem in the same way.

Most snakes can climb and many are very excellent climbers. Some spend nearly all of their time above the ground. In order to climb well an animal should be able to ascend an upright tree trunk, move along a horizontal branch, and cross from one branch to another.

A young boa constrictor is an excellent demonstrator of methods used by heavy-bodied snakes in climbing. Three experiments with one of these beautiful snakes will show how well it can climb. A boa constrictor is used here because it performs so nicely; many other kinds climb just as well. Almost any powerful thick-bodied constricting snake will do moderately well. Instead of giving the boa a tree or bush we will make conditions even harder and thus severely test its ability.

First, place the boa on an upright stick or pipe one or two inches in diameter extending from the floor to the ceiling. The boa will find no difficulty in ascending by gripping the pipe with a coil of the rear part of the body while the forward part is reaching upward. After securing a new grip with the front part of the body, it draws the rear end up for another new hold. How simple! Also how easy it must be for this snake to climb a rough branch or bush if it so readily ascends a smooth pipe. A snake is, however, quite unable to climb an upright tree with perfectly smooth bark unless the length of the snake greatly exceeds the circumference of the tree.

Second, stretch a large cord or small rope tightly across the room and lay the snake out along it (see illustration following page 76). The boa does not fall off because it allows enough of its body to hang below the rope to keep the center of gravity low. In other words, it can stay on the rope for the same reason that you can straddle a horizontal bar in the gymnasium. But just try to stand on that same bar! By straddling you lower your center of gravity about two feet and thus keep yourself from getting a bad fall. In order to move along the rope or cord, our boa must use the caterpillar movement for obviously it cannot use the undulatory one. Crawling along a branch must be much easier than crawling along a rope or cord.

Third, get two ladder-back chairs or any other objects that afford a good gripping place for the boa and stand them two or three feet apart. Put the boa on one and wait until it decides to try to get to the other. (You may have to wait a long time.) That head and neck can stretch way out without support and it is surprising what a large space the boa can span. In this way it crosses from branch to branch while climbing about in trees. (See the illustration facing page 80.)

In strong contrast to the boa constrictor and other heavy-bodied climbers (see illustration facing this page), many tree snakes have become good climbers without being muscular acrobats. They have reduced their weight by growing astonishingly long and slender. (See the illustrations facing this page.) Now, a little weight can be extended along or across many leaves or twigs without weighing them down. This is exactly what these snakes do—they stretch themselves across foliage and move almost as they would on the ground, that is, by the undulatory movement. They cannot fall through any more than you could drop a length of cord through a thick bush or hedge. Any good reptile house is sure to have one of these snakes—several kinds exist—and the sight of one is worth a trip to the zoo. Even the blacksnake, blue racer, coachwhip, and related snakes of the United States can glide through brier patches, thick bushy growth, and hedges with surprising agility. I have seen an alarmed blacksnake shoot up to the top of a six-foot bush just as though he were using it as a point from which to watch the movements of his pursuers.

As far as I have observed all snakes of moderate to large size can swim well. They use the lateral undulatory movement in doing so. Snakes exhibit all stages of fitness for aquatic life as shown by the illustration facing page 32. On one extreme, there are those that enter water only when frightened or in pursuit of prey; on the other, there are the sea snakes which live in the sea and have tails broadly flattened from side to side.

Nearly all of the sea snakes are helpless on land. They inhabit the region from the coasts of southern Asia southeastward to Australia and the Pacific islands. Although often met with in the sea far from land, they are essentially inhabitants of large ocean bays, coastal waters, and the vicinity of islands. This is shown by the fact that, although some fifty species inhabit the Asiatic-Australian region, only one, the yellow-bellied sea snake, has succeeded in crossing the ocean and reaching the western shores of Mexico and Central and South America. No one knows when this species reached the New World or how long it took to get there. The crossing was probably a very gradual one and, judging by the rather wide distribution of the species along the coasts of North and South America, took place many thousands of years ago.

Watching a snake get out of a knot by the simple method of passing the knot along the body until it goes right off the tail gives the impression that the bones of the snake's back must be very loosely attached one to another. This impression is entirely wrong, for the vertebrae of all snakes are well and firmly joined together or articulated. In fact, they have an extra articulation to insure firmness and prevent twisting and too much freedom of movement. A snake can bend double or be none the worse for having been tied in two or three knots because of the large number of bones or vertebrae in its back, not because there is a great deal of freedom of movement between the individual vertebrae. (See the illustration facing page 24.)

To prove this, take a snake, bend it double and count the number of belly plates involved in the bend, recalling that there is one vertebra for every plate. Remember that snakes have no true limbs so their vertebrae are almost or entirely free of shoulder and hip bones. In man, the shoulder and hip bones support the limbs and (together with the ribs) cause parts of his backbone to be more or less rigid.

The bones of a snake's back are nearly alike from the neck to the end of the body and in some species there are more than three hundred of them! I feel sure that I could bend double or put up with being tied in a knot if I had 300 bones in my back instead of only thirty-three or four! As a matter of fact, not counting my neck, I, like you, use only five vertebrae in bending to the side; the other twenty or twenty-one do not help in lateral bending.

If you recall that, in moving along the ground by the undulatory method, a snake's body always lies flat you can realize why it is necessary for the snake to have vertebrae joined firmly enough together to prevent twisting. If the vertebrae twisted one on the other, the snake's body would twist and, instead of moving it forward, the sidewise pull of the muscles would only cause the belly to turn upward.

You could never make an ordinary chain crawl no matter how many muscle-like strings and bands you attached from link to link because the links are not articulated in the same manner as the bones of a snake's back.

In Central China, I used to have great sport chasing snakes. One kind, a large species named *Zaocys,* was able to give me a good run; down bank, across ditch, through stream and thicket it would dash but only to stop suddenly when well hidden, leaving me puzzled. Upon my too close approach to its hiding place, off it would dash again with me hot in pursuit until, with luck, I approached near enough to fall upon it and extract it from sticks and grass or even brier and thorn. I recall being able to catch only about half of those flushed.

This account sounds as though snakes were fast travelers, and indeed they have the reputation of being such. The glimpse of a slender form disappearing through grass or bushes certainly gives the impression of real speed. Walter Mosauer, not being satisfied with guesses and impressions, has undertaken to find out accurately just how fast several American snakes can go. His results are surprising to everyone, and, to those who hold the snake up as a "speed demon," disappointing. He found that the western whip snake, by far the fastest, crawls at a rate of 3 miles per hour, but prowls only at the rate of a quarter of a mile per hour. The California boa can progress only one-sixteenth as fast as the western whip snake and prowls at a snail's pace! The running of the Pacific bull and patch-nosed snakes probably represent average ability, both able to do a little better than the rate of a mile an hour. None of his snakes could keep going for any great length of time but weakened after a few trials.

What slow movers snakes really are! A race horse can cover nearly a mile in a minute and a half (just under 40 miles per hour) and greyhounds run almost as fast. Roy Chapman Andrews proved that the desert gazelles of Mongolia can maintain a rate of 60 miles an hour for half a mile. The fastest wolf he followed attained a 36-mile-per-hour rate for a short distance. Man himself easily walks 3 miles in an hour and sprints for a hundred yards at the rate of 20.5 miles per hour or better.

The ability to jump forward is seldom met with in snakes but there are a few exceptions such as the jumping vipers of the American tropics, a boa named *Enygrus asper* of the New Guinea region, and the carpet viper, which is found in Africa north of the equator and in southern and southwestern Asia. The carpet viper is even said to spring from branch to branch when climbing about in bushes. The New Guinea boa sometimes jumps at its prey, and one species of jumping viper can cover a distance almost equal to its length. Fortunately, the latter is usually only about two feet long.

While hunting snakes on an island in the Bismarck Archipelago just east of New Guinea, Heini Hediger collected a kind of snake that, according to the natives, often flew down from palm trees some 50 to 60 feet high. This aroused Hediger's interest and caused him to make a study of previous accounts of flying snakes, especially as three other oriental species are supposed to be able to fly. He concluded that these snakes only hurl themselves out of trees or bushes and thus make long jumps from high places. Being light they are not hurt when they land but quickly move off to safety. Some Asiatic and East Indian lizards are true gliders but they, in strong contrast to snakes, have a large wing-like flap of skin between the legs on either side. This flap can be folded up or stretched out at will.

10

DEFENSE

No doubt shape has a lot to do with the serpent's cowardly attitude toward danger. Suppose you had neither arms nor legs and were shaped like a rope, how would you defend yourself? Can you think of a dozen good ways without counting constriction—oddly enough a snake seldom constricts anything that it does not intend to eat. You will soon see that, in spite of a simple shape, snakes have worked out many more than a dozen defensive methods.

An interesting thing about these defensive habits is the way the same one will be used by unrelated snakes from different parts of the world. As a group snakes are like a magician with just so many tricks in his bag; he can do those and no more.

One of the neatest tricks done by any snake is making itself into a compact mass, the head in the middle of many protecting coils. The rubber snake of the extreme western United States does this so well that it can be rolled about and has won the name of ball snake. Being a boa, it is in no way related to the Chinese chain snake which has the same habit. In fact many a snake includes this trick in its show.

Another protective habit is to hide the head under the body. The horn snake of southeastern United States (see illustrations facing this page) and the deadly kraits of Asia and the East Indies do this in much the same way but with the latter a degree of deception may be involved. The hiding of the head protects that vital part and gives the krait a good chance to bite anything foolish enough to seize the body.

Strangely enough, these deadly snakes are extremely good-natured, and two among five that I secured in southern China could not be induced to bite under any circumstances. Teasing only made them jerk about, pushing the head under first this and then that part of the body.

The common species of India is quite as docile even though one of average size carries enough poison to kill five healthy men.

So much for protective positions; deception and strategy come next. The simplest method here is to become perfectly still, to "freeze," a trick practiced by many species, among them our pilot black snake. Everyone knows from experience that the eyes often pass over a motionless object even though it does not match the background. This is especially true when many other objects are lying about near by. Thus a snake among sticks, leaves, or rocks is easily overlooked as long as it does not move. Test this with any snake, preferably a dead one. You might see how close your cat or dog will pass to one. When the snake matches the background, as a green snake in green leaves, the perfect deception is, of course, as much the result of protective coloration as of lack of motion.

A few snakes have made even better use of the idea of becoming still. In the Philippine Islands a certain species that likes to live in fallen trees makes itself rigid and drops to the ground when frightened. This would not be so clever if the colors and slender form of the snake did not make it look like a dead twig with lichens growing on it. The falling and stiffening increase the natural resemblance to a stick, making the deception all the better.

This habit of the Philippine snake is very close to the better-known playing 'possum or feigning death. The supposedly dead snake, however, usually gives itself away by insisting upon lying on its back; turn it on its stomach and over it rolls! The hog-nosed snakes of the United States and Mexico play dead exceedingly well until turned back on the stomach. (Illustrations facing page 84.) They leave out no detail, even writhing about in mock death agonies before turning turtle. The tongue is also used; it is allowed to hang out and become covered with dust. All reptile men know that no living snake ever lets dirt stick to its tongue under ordinary conditions.

The ringhals of Africa, one of the "spitting" cobras, likewise shams death but gives itself away by keeping one eye directed toward the enemy. It may not be fair to say that the ringhals and the hog-nosed snakes spoil their tricks. What animal besides man would ever turn a snake over to see whether it were dead? The ringhals may be luring the enemy close enough to be a better target for a fresh stream of venom. These snakes have many enemies less intelligent than man.

The tails of most snakes are long, slender, pointed, and useless except as a place in which to keep certain glands and the male sexual organs. Many slender species lose the last third of the tail without missing it in the least. But all snakes have not overlooked the possibilities in tails. The most useful tails are both short and blunt, as, for example, the tail of the rattlesnake.

Almost as remarkable tails are possessed by the burrowing shield-tailed snakes of India whose blunt hind ends are protected by a hard rough shield. No one knows just how these shields are used but it has been suggested that the snakes lie in their burrows so that the shield fills the entrance and prevents anything from invading the burrow. At any rate an enemy overtaking one of these snakes underground would have the shield to contend with first.

By far the cleverest use of a tail is to make it mimic a head. To do this best the tail must be shaped and colored like a head. The tail of the so-called two-headed snake of China is not only shaped and colored to match the head but behaves more like a head than the head itself. When I seized one of these snakes by the tail it only tried to escape but when I held it by the other end, the body wrapped itself around my fingers while the end of the tail was repeatedly pressed against them as if trying to bite.

In some species the tail is held up and moved to and fro in imitation of a head. The common black snake of Australia, a moderately poisonous relative of the cobras and coral snakes, strikes with its tail even though that appendage is not especially short or blunt. P. J. Darlington pulled one of these reptiles from under a log in the evening twilight and put his foot on its neck. He was startled the next moment to feel it viciously striking his foot, each strike landing with a thump. The strong impulse to let the captive go was checked long enough for a quick examination to show that the snake was striking with the tightly looped end of the tail. The trick had almost worked.

A few methods used by snakes defy classification. One of these is the habit of writhing and twisting about like a contortionist gone mad. Unless this confuses and bewilders an enemy I scarcely know what its purpose can be. A fine performance of this kind is put on by the little hook-nosed snake found from western Texas to Arizona. Edward H. Taylor, one of the few persons to collect a specimen, writes that, "immediately on being touched it began to writhe and to throw its body in strange contortions, as if in agony, sometimes almost throwing itself off the ground. It would continue these actions for several seconds and at the same time it would extrude and retract the cloaca rather rapidly, for a distance of half an inch or more, which resulted in a popping sound."

Snakes are first cowards, next bluffers, and last of all warriors. In fact their ways of trying to frighten rather than hurt an enemy are surprisingly numerous. The starting point for a good bluff is generally an attitude that says: "Look out, I mean business." (See illustration facing page 90.) Each species has its own threatening pose which serves as a background for still more alarming hissing, spreading, inflating, opening of the mouth, or even striking—with the mouth tight shut. The hog-nosed snakes of the United States strike viciously enough but their strokes are only harmless butts. Of course if the teeth were brought into play we could not include these snakes in this consideration of bluffers; they would be true biters.

Sudden changes of shape involving head or body or both head and body are favorite bluffing actions. These changes are the result of inflation with air or "erection" of the ribs, that is, moving the ribs forward. This motion of the ribs widens the neck along with more or less of the body. The hood of the Indian cobra (see illustration facing page 91) is the best example of a flattened or expanded neck, but this cobra is only one of many snakes that use the trick. In some species the head and much or all of the body are "spread" along with the neck. (See illustration facing page 84.) A flattened head has an especially sinister arrow-head shape.

Inflating or blowing the body up likewise is a common habit. The neck and forward part of the body are sometimes made to look like a sausage balloon. But how is this done? The trachea or windpipe of all snakes is provided with rings of cartilage which are incomplete on the upper side. In kinds that inflate, the membrane closing this upper side by connecting the ends of the rings is readily expansible. After filling the lungs with air the glottis or end of the windpipe in the mouth is closed and the air forced out of the lungs into the membrane of the trachea.

It is hard to imagine how fierce an inflated snake looks. One should visit a zoo and ask for a demonstration; I can think of no native snake that puts on a really good ballooning show. Most species become tame so quickly that even a big zoo may be temporarily unable to satisfy you.

Making a noise is still another way of putting up a bluff. Here snakes are chiefly handicapped by a lack of vocal cords; their simple shape and limblessness also make the production of sound difficult. Nevertheless, even aside from using the lungs, they have learned to make a noise in two entirely different ways. Can you guess what they are? One is by rubbing the scales together, the other by vibrating the tail.

In the few snakes that give the scale-rubbing performance, several rows of scales along either side are set obliquely. A saw-toothed ridge or keel runs down the middle of each oblique scale. When aroused the snake inflates, throws its body into a position suggesting the figure eight, and, holding the head in the center, moves or "revolves" without spoiling the figure-eight position of the body. This motion rubs the oblique scales together and produces the characteristic hissing sound, the inflation increasing the vibration not a little. The snake is thus turned into a primitive musical instrument. Wall tells of raising the lid of a large pot containing several saw-scaled vipers. The noise that came out sounded like violently boiling water. The effect was truly uncanny since no steam issued forth and the pot was cold.

I feel sure that the first snake's tail was vibrated through pure nervousness. After all, a boy can show excitement or fear in dozens of ways—picking fingers, biting lips or nails, wriggling, and so forth. A snake has limited possibilities and moving the tail is certainly a most natural thing for it to do under emotional strain. The facts bear out my theory since hundreds of species vibrate the tail when alarmed.

One of Mother Nature's cleverest feats is to take a useless habit or structure and make it useful. Starting with this tail-shaking habit, she has developed the rattlesnake's rattle, the most efficient sound instrument that snakes can boast of. A large rattler is audible at a hundred yards. Some individuals can rattle with only momentary pauses for half an hour or longer.

It is impossible to say how much use rattle-less snakes make of the tail-vibrating habit. They produce a fairly loud noise in dry leaves. Only the other day I flushed a large blacksnake that made off and hid in a thicket. I promptly lost sight of it until the noise made by its tail enabled me to find it again. (See the illustration facing this page.)

The simplest way for a snake to make a noise is by hissing, and indeed the words snake and hiss are generally thought of together. Ask one of your friends to tell you the first word that comes to mind when you say "hiss." It will probably be "snake."

The hissing of snakes ranges all the way from the short sharp s-s-s that the cobra makes as it strikes to the loud sustained warning hiss—like the sound of a leaking football—emitted by an aroused Russell's viper. This reptile produces as much noise blowing out as drawing in. Wall found that it could not make its warning sound after its nostrils were stopped with wax.

The American pine and bull snakes rate high as hissers but with them the nostrils play no part, the air being expelled violently against the side of a small flat structure that may be readily seen on the floor of the mouth immediately in front of the glottis or end of the windpipe. (See the illustration facing this page.) This flap divides the stream of air and increases the volume of the hiss. The sound made by these snakes is popularly called a bellow but it scarcely warrants such a grand name. The dhaman of Asia not only hisses but makes a noise that has been variously likened to the deep growling of a large dog, a cat at bay, and a vibrating tuning fork!

The most remarkable way in which a snake frightens a foe is by suddenly confronting it with a brilliant array of so-called flash-colors. Such a display not only surprises but scares most animals and adds to the alarm caused by hissing, inflating, spreading, or other threatening postures and movements. Both inflation and spreading separate the rows of scales bringing to view colors of the skin that ordinarily remain concealed. These combine with those of the scales to form bars, spots, or even complex figures such as the spectacles of the Indian cobra's hood.

Not a few species with strikingly adorned under tail parts show flash-colors by merely raising or curling the tail so that the pattern of its lower side comes into view.

The most famous exponent of this tail-raising method is the red snake of the East Indian region. When alarmed, this harmless snake holds the head against the ground but raises and flattens the tail so that the crimson of its lower side shows conspicuously. The tail may be curled or simply held erect. There is much speculation by herpetologists as to the purpose of these actions: Some believe that the red snake mimics a young cobra, others that it copies a certain poisonous snake that raises the tail in a similar way and inhabits the same part of the world. Still others agree with me in holding that these tail-lifters are not imitating other snakes; all have merely learned the same stratagem. The tiny ring-necked snakes of the United States use their tails in much the same way without a poisonous species to mimic.

Long after passing the diaper stage young children wet or soil their clothes when scared or greatly excited. Adults often do the same thing if frightened badly enough. In fact this is a common result of great emotional strain in animals. Just as in the case of the tail-vibrating habit, Mother Nature has made a stepping stone out of a stumbling block; she has taken this uncontrolled voiding of excrement and turned it against the enemies of snakes.

One of my earliest recollections of snake handling impressed itself on me deeply because it embarrassed me beyond description. On my way home from Sunday school I stopped to "show off" with a pet common king snake. My audience included girls as well as boys and, as if realizing this, my snake did its worst. It decorated my Sunday clothes and reduced me from a hero to a laughing-stock. One soon learns, however, to be prepared for such a demonstration and there is nothing to fear when prepared.

Some snakes thrash the tail around as they void large quantities of both solid and liquid excrement. I believe that, like man, most other animals recoil violently from any foreign matter ejected upon them, and of course there is always the possibility of its getting into eyes and mouth. Like tail-vibrating, this squirting in some cases may be only a nervous habit, but many snakes do it so well and so frequently that with them it must be classed as defensive.

So much for indirect defensive methods such as deceiving, frightening, and other sorts of bluffing; now we have arrived at the more serious business of trying to injure an enemy.

Snakes first and foremost use their teeth. These are most effectively brought into play by a forward jab of the head. There are two fundamentally different ways of doing this; one is developed to its best by the cobras, the other is used by innumerable snakes. The cobra simply rears, keeping its elevated forepart straight, the neck just behind the head being bent enough to bring the enemy into view; the tail and remainder of the body rest on the ground to support the elevated parts. The stroke is a simple forward jab that necessarily carries the head and neck downward as well as forward. (See illustration facing page 91.) The disadvantages of this type are many: An upward thrust is impossible so the cobra cannot defend itself from a sky attack; the range of the stroke is quickly gauged by an adversary and cannot be easily regulated, allowing an aggressive enemy such as a mongoose to step into a close zone of safety; no great speed or force can be attained by the stroke.

The other and commoner way is to draw the head back, raising it but little and bending the neck from side to side in S-curves. Sometimes the body is evenly coiled under the loops of the neck but it may be held in any curved position. The stroke from this posture is too fast for the eye and its range easily regulated. The adversary can find no close zone of safety nor can it judge the extreme limits of a thrust. A fairly efficient stroke can be delivered upward. (See the illustration facing page 95.)

The actual bite comes at the end of the stroke, the jaws being opened as the head moves forward, closed on the victim, opened, and finally closed again during retraction of the head. A few snakes start the stroke with open mouth, others hold on, and still others chew.

The Sonoran racer has an unusual technique: having secured a hold it loops the neck and jerks vigorously enough to tear skin and flesh. Certain species have still more drastic methods. For example, the Theban sand-boa strikes with a series of lightning-like sidelong movements that inflict deep slashes and cause profuse bleeding. According to Flower the hands of a man who innocently tried to pick up one of these snakes were literally streaming with blood before he had realized his mistake. The popular belief that a snake must coil to strike or bite is erroneous. Some species, such as the kraits of Asia, bite by simple side-swipes that are independent of coiling. A snake that has a characteristic defensive pose of course bites most efficiently from it, just as a prize-fighter delivers the heaviest blows from his best fighting position.

Of all the fiendish methods that snakes have developed none is perhaps more terrifying than the so-called "spitting" of venom. The term "spit" is, however, misleading because the venom is squirted rather than blown out. It always lands on a nearby object in two separate streams; at a greater distance these streams join to form a spray.

Cobras are the only true spitters. Although nearly all cobras appear to be able to eject their venom to some extent, only the ringhals and black-necked cobras are definitely known to prefer spitting to biting. The combined distribution of these two snakes covers all of Africa. One cobra of the Malay region may also spit more than bite; its habits are not well known. A few true and pit-vipers have rarely been known to eject drops or even jets of venom. I know of one case that was the accidental result of a stroke stopped by wire mesh.

It was once thought that a mixture of venom and saliva was ejected by spitting cobras, but experiments have proved that pure venom is thrown out. These snakes invariably direct their jets of deadly liquid at the eyes of an enemy, and their aim is astonishingly good. The ringhals has a range of six or seven feet and can spit repeatedly within a few minutes' time. Arthur Loveridge tells of an encounter with a black-necked cobra that "spat between a dozen and twenty times, and its venom was in no way exhausted right to the end, for when putting it into a bag, it nearly hit Salimu who was holding the bag for me."

Venom that lands on the skin ordinarily does no harm, that received in the eyes gives excruciating pain and temporary blindness. Bad effects of a permanent nature such as watering of the eyes under slight strain or even blindness may result. A pair of goggles affords perfect protection for the eyes. This spitting must be counted as a defensive habit because it drives an animal away instead of assisting in its capture. There are few more effective methods of defense since the fiercest or most active enemy when blinded in such a painful manner would be easily escaped.

Loveridge has caught numerous black-necked cobras and heard many first-hand stories of encounters with them. Four experiences briefly related by him follow:

"I know of a family residing near Nairobi in which nearly every member, and many employees about their farm, have been spat at in the eyes at one time or another. I wish to emphasize this point that the cobra deliberately aims at the face, as only recently I read in a journal that it was a matter of accident when the venom reached the eyes. The lady of the household referred to, on going to the fowl-house, where it was none too light, saw something dark in one of the boxes, and supposing it to be a fowl she bent over it and received a charge of venom full in the face, the resultant shock and pain was so great that she could only sink on her knees and call for help. Her husband arrived and with a shot-gun blew the snake to pieces.

"One evening I was having dinner in my grass hut. Outside, though only six feet from me, Salimu was squatting in the beam of light from a powerful acetylene lamp. He was engaged in extracting a nail from a box.

" 'Hapana mzuri,' said he, standing up.

" 'What's no good?' I asked, as he stepped inside.

" 'Cobra,' he replied in the vernacular.

" 'Where's a cobra?' I inquired abstractedly.

" 'Look,' and he exhibited some glistening drops of venom on his arm. 'It is not raining, *Bwana,* and I heard it hiss.'

"Apparently a cobra had come out of the loose stones of which the terrace was constructed and 'spat' at him, startled into doing so no doubt by some sudden movement on his part.

"A friend of mine was crawling through some grass to obtain a final shot at a hartebeest which he had wounded. Suddenly up rose a cobra before him, he had presence of mind to tightly close his eyes and received the venom upon his eyelids. Lying back, he awaited the arrival of his syce, whom he instructed to take his water bottle and pour its contents on his face. Then, after a careful sponging with a wet handkerchief, he opened his eyes and was none the worse for the unpleasant experience.

"A keeper in the gardens of the Zoological Society of London received a box of snakes from West Africa. Seeing there was netting beneath the lid, he started to pry up the slats, when he received a charge of venom in his eyes at very close range. A year later he was still suffering from the effects, his eyes looking weak and watering at the slightest strain. He informed me that he could never read by artificial light in consequence."

11

ENEMIES

SNAKES AND mankind have the same arch-enemy: man. Snakes have more right to be terrified of man than man of snakes. But whereas the snake often does not know enough to be afraid, a man's fear of a snake is usually due to ignorance.

When a king snake kills a rattler, it is no more guilty of murder than a man is when he kills a gorilla. True murder is certainly more common among men than among snakes. Real cannibalism is often observed among captive snakes but I dare say it is practiced more frequently by man than by wild snakes.

I did, however, once almost catch a cannibal Chinese snake in the act. While walking through a bamboo forest on a mountain I had my attention attracted by a sliding sound like that made by a snake gliding over dry leaves. I rushed toward the sound just in time to see a large snake slip under a rock. After pulling it out I noticed that it had something in its stomach. A gentle pressure along its belly made it disgorge alive and little the worse for wear a smaller specimen of its own kind.

Men have always waged war on snakes and there is no way of knowing how many millions of harmless individuals are battered and shot to death every year. Thousands are cooked and eaten. Few people object to the destruction of the dangerous kinds but it is a shame to kill the harmless ones. There is a sure rule: As the animals and plants of a region are destroyed that region becomes more and more barren and uninteresting. If not, why do governments spend millions of dollars setting aside whole sections of wild country so that their fauna and flora can be properly protected and preserved?

Some people will answer: "Yes, but only the beautiful and useful animals should be protected," and my reply is: "Killing is a habit and once people start they stop at nothing. Few persons have the same ideas about usefulness and beauty. The decision should be left to experts." I know a boy who first hid himself and then cried bitterly after his mother had made him kill a badly wounded common garter snake to end its suffering. I think more of this lad than the boys who stone every little snake they find. I must admit, though, that the parents rather than the boys are to blame for the stonings.

Unfortunately no amount of teaching people not to slaughter harmless snakes will keep automobiles from running over them. (See the illustrations facing page 100.) The total killed by cars is almost unbelievable. Bull snakes are the best friends of the American farmer as well as one of the kinds most often left dead along our roads by cars and their occupants. Mr. Klauber made careful calculations for San Diego County, California, and estimated that autos kill 10,000 snakes each year in that county alone. If this same rate holds good for the rest of the United States nearly 6,000,000 snakes must be mashed out of existence every twelve months! Trains add to this total, possibly bringing it to well over 6,000,000. The victims are again partly to blame. They like to lie in the sun of roads and tracks during the spring and fall months and are seldom alert enough to avoid destruction.

The smaller tropical snakes are fortunate in living where automobiles and trains are not numerous. Large species of the tropics are anything but lucky, for there leather hunters look for them incessantly and hundreds of thousands of skins are collected every year. Pythons and the karung of southern Asia and the East Indies are the chief victims. These are harmless. No large snake is safe from the collectors who are ever on the lookout for new kinds to add to their lists.

Next to man snakes are their own worst enemies. The reason for this may be that a snake is ideally shaped as food for another snake just as all-day suckers are made to fit young human mouths. The fact that snakes are extremely fond of elongate lizards bears my theory out. I once took two snakes, one five feet, the other one foot long, out of a five-and-a-half-foot Chinese snake-eating species. There are many recorded instances of snakes eating others larger than themselves, but a 200-pound python has to do its best to devour a pig or goat weighing from 50 to 75 pounds. It is chiefly a matter of shape. If an animal could assume any shape it would do best to make itself perfectly spherical when attacked by a snake. It would be hard to hold as well as to swallow. Indeed some toads seem to understand this principle for they swell up when seized by a snake.

Wall's book on the *Snakes of Ceylon* tells what food thirty-eight kinds of Ceylonese land snakes eat and just nine of this number prey at least in part on other ophidians. In China only twelve species out of seventy-six about whose appetites we know are snake-eating. Sea snakes are not known to eat other sea snakes; they eat elongate fishes instead. This is especially interesting because their closest relatives, the cobras and coral snakes, are notorious lovers of a snaky diet. No one has ever given a complete account of the feeding habits of American snakes, but our king snakes, coral snakes, and racers are well-known snake eaters. (See the illustrations facing page 101.)

Snakes sometimes eat eggs of other species. An African blind snake has been known to do this, and one whole group of Asiatic serpents is very fond of reptile eggs. It may be that chiefly lizards suffer from the peculiar appetite of this group; partly digested eggs are not easily identified.

As a wholesale destroyer of snakes the king cobra or hamadryad probably ranks first. It all but specializes on this diet and devours along with harmless ones such dangerous reptiles as kraits, Asiatic coral snakes, and smaller cobras. A thirteen-foot king cobra was once shot while swallowing a python eight feet long. Nature was extremely ironical when it made one of the most dangerous snakes of the world the champion destroyer of its own clan.

All this might lead one to think that many a glorious fight is staged in the snake world but such is not the case. When hungry snake meets snake the usual result is anything but exciting. It may even be like a one-round prize-fight stretched out to two hours as a slow movie. The victim does not always seem to be greatly concerned with what is going on but, like a Christian martyr of old, succumbs without show of pain.

Not only the most dramatic snake fight I know of but the only one on record which had a reptile audience is described by Gloyd. A blue racer seized a copperhead and began to chew its head and neck so viciously that the victim thrashed about wildly in an effort to escape. After the struggling had ended, the blue racer spent an hour swallowing its prey. All the while a lizard watched from a nearby rock, showing great curiosity and excitement. When the snakes made especially violent movements it would dash away in fright only to return again to peer over the edge of the rock at the fascinating spectacle.

In Germany on July 1, 1934, Viktor Zebe watched a pair of serpent eagles tend their brood. At 6:35 A.M. the male brought a snake to the nest and about two hours later it appeared with something else, probably another snake. Again at 10:20, 1:20 P.M., 3:00, and 4:00 snakes were brought to the young. In other words, these nestling serpent eagles were fed six snakes in less than ten consecutive hours. The father bird thus proved itself to be a first-class snake collector. One is safe in saying that it could catch a snake in less than an hour because during those ten hours it spent much time at the nest. Although other animals were eaten, snakes undoubtedly made up the bulk of the food of this family, which may have consumed as many as three hundred in one month.

Fortunately for snakes at least, there is no bird that eats only ophidians. In fact, over the earth few birds are known to compare to the serpent eagles in this respect. Not a few large birds or birds of prey take snakes along with other small animals, but for every snake-eating bird there are many bird-eating snakes.

The feeding habits of the common species of hawks of the United States are well known; about half of them eat snakes. The broad-winged and red-shouldered hawks are fonder of snakes than any others. Circular No. 370 of the United States Department of Agriculture shows that one out of every five to seven dissected stomachs of these two species holds snake remains. When it comes to hawks, farmers and snakes have the common problem of learning which ones to distrust. The two chief hawk enemies of serpents happen to be mainly beneficial to man, but in no case is a hawk rated as useful because it preys on snakes. Indeed no poisonous snake is mentioned as having been found in any of the 3693 snake-eating hawks whose stomachs were examined by government workers. This does not mean that poisonous kinds are not occasionally caught.

The handsome and graceful secretary bird is the most famous of all feathered snake eaters and enjoys protection by law in part of Africa for this reason. It is said to defeat snakes by first allowing them to waste their poison on the long feathers of an outstretched wing before killing them with its feet.

I read dozens of descriptions of this without finding one that seemed to have been written by an eye witness so I went to Mr. Crandall, Curator of Birds in the Bronx Zoological Park, New York. Mr. Crandall has watched many secretary birds attack snakes and believes that only the feet are used. The wings are held out to help balance the bird as it dances about fending for a chance to strike. This bird, which stands three feet high and has a wing-spread of seven feet, is so agile and quick that it easily dodges the strike of the snake and soon pounds it to death with terrific blows of the feet. The poor victim has little chance.

This is certainly no pleasant way to die, but there is little choice between being battered to death and swallowed whole, which is the way birds such as the black-crowned night heron eat snakes. John T. Nichols once watched a common water snake disappear by degrees down the throat of one of these birds on Long Island. The head of the unfortunate snake was last to vanish and Mr. Nichols watched the swelling caused by the snake as it moved stomachward.

It is not hard to learn that a good number of mammals or furred animals kill some snakes but it is surprisingly difficult to determine in any case how much damage to the snake population is actually done. Opossums, armadillos, skunks, cats, dogs, badgers, and countless other mammals destroy snakes to some extent. Hogs have long been known to devour poisonous as well as harmless ones, and deer destroy them by stamping them to death. In addition to these numerous foes, there are a few mammals that, like hogs, take great delight in killing and eating snakes.

The hedgehog of Europe and Asia attacks and devours a snake as calmly as a business man drinks his coffee. The hedgehog can do this chiefly because of a thick coat of spines putting that of the porcupine to shame. Moreover, the hedgehog enjoys a certain degree of immunity to the poison of some snakes and is thus doubly protected. A kind of South American skunk, the cangamba, seems to be even more immune to bites of South American pit-vipers. The irara, a Brazilian fox, has also been found to resist the venoms of some Brazilian snakes which it eats.

Few people realize what fierce animals house rats are. Cats generally prefer to leave the large ones alone and many a deadly snake has been killed by them. They often attack snakes at sight and quickly devour small ones. Even mice kill snakes. I have seen a white mouse all but gnaw the head off of a large timber rattlesnake that was in fairly good condition. A mouse has been known to kill a ringhals "spitting" cobra by gnawing while riding the snake's back. The saw-scaled viper of Africa and Asia grows to be two feet long and is one of the fiercest snakes known. Wall tells how a house rat fought and killed three of these snakes without receiving any injury whatsoever. In spite of all this, snakes constantly eat young rats and mice and scores of species prefer tender rats and mice to any other food. Adults are also eaten. It seems to be a question of size and strength, for an eternal state of war exists. No quarter is ever given on either side. The strife begins at birth or when the eggs are laid. Snakes undoubtedly find the nests of rats and mice by trailing the adults, and rats have all but exterminated certain snakes in parts of Germany by eating their eggs and young.

Just as, to most people, the secretary bird is the feathered champion fighter of snakes so the mongoose is the popular champion among the mammals. This is largely due to Kipling's story of Rikki-tikki-tavi. I witnessed two cobra-mongoose fights in China and found them to be anything but exciting. In both cases the two animals faced and bit each other viciously. The mongoose generally gave bite for bite and the mouths of the combatants were often interlocked. The mongooses were careful to face the snakes constantly and were never bitten anywhere but about the mouth. The movements of cobras are comparatively slow, so their enemies seemed always to have the advantage. The mongooses held on longer and chewed more as their opponents grew weaker and weaker. If, however, a cobra succeeds in biting a leg or the body of the mongoose the latter may succumb as it is only relatively immune to the venom. Calmette killed one in twelve hours by injecting it with eight times the amount of cobra venom that kills a rabbit or hare. In one of the two fights that I staged the cobra was only some three feet long, the mongoose a large one; in the other the snake much longer, the mongoose smaller. In the first fight the cobra was killed and the mongoose lived; in the second the mongoose died but not, as far as I could tell, from the effects of bites.

Deraniyagala watched a fight in Ceylon that must have been essentially like those seen by me. The chief points noted by him are: The mongoose, fighting in rounds of about five seconds, never attacked the cobra's body and met rather than avoided its bites. The mongoose seemed to realize that it was safest at very close quarters. This is due to the fact that a cobra cannot well shorten the length of its strike. The amount of rolling about depends entirely on the relative weights of the combatants. A large cobra when seized by a small mongoose may roll and twist or even wrap itself about its opponent.

Sixty to seventy years ago the mongoose was brought to Martinique and St. Lucia to destroy the fer-de-lance and did its job fairly well, probably by killing young snakes; staged fights with big fer-de-lances often prove fatal to the mongoose. Soon after, it was taken to other West Indian islands to combat plagues of rats. In some islands it proved to be useful; in others the rats became arboreal and escaped whereas the mongoose turned to the destruction of fowl and useful birds, toads, and lizards.

On Trinidad, where large tropical forests afford retreats for poisonous snakes, the mongoose has not affected the dangerous coral snakes, bushmasters, and fer-de-lances but has been found in the stomachs of full-grown boa constrictors. It is now suggested by Urich that this snake be protected and used to help rid Trinidad of the mongoose. First taken halfway around the world to destroy snakes in the West Indies, the mongoose is now the cause of a movement to protect snakes there so that *they* may destroy *it*. What an unfortunate creature the mongoose is and how fickle is man!

I collected in southeastern China twelve specimens of a certain large snake, but only one of the twelve had a complete tail. In Africa, Loveridge once found that half of the snakes from one place had short tails whereas all the tails of a series from another place were undamaged. Some snakes of the Galapagos Islands have been found ninety percent short-tailed.

What does this mean? Has each of these damaged snakes saved its life by leaving part of its tail in the mouth of an enemy? If so, what enemies are responsible? Here is an unsolved problem. Both Loveridge and Mertens have suggested birds as the most likely tail nippers but it would be good to have definite proof. I would guess that mammals are to blame in many cases.

In Louisiana Mr. McIlhenny has seen mother alligators crunch large snakes to pulp and then hold them at the water's surface while her young tore off pieces and swallowed them. He believes that 'gators all but exterminate water snakes in certain ponds. Crocodiles are known to do their share in eating snakes.

The stump-tailed lizard of Australia is alleged to kill poisonous as well as harmless kinds. It grows to be over a foot long and has a tail so much like its head that one wonders how it knows which is which. The American bull frog and other large frogs and toads eat small snakes and even sharks get their turn at sea snakes.

In Mexico Dr. Krumm-Heller watched a spider get its bearings by letting itself down repeatedly from a branch over a sleeping rattlesnake. After being satisfied that it was just above the spot to be bitten, it descended, delivered its bite, and quickly climbed its thread again. The snake writhed and rattled for a time and then lay motionless, presumably fatally wounded. A giant Brazilian spider attacks and kills pit-vipers a foot and a half long. After doing this it sucks their juices, a process that may require twenty-four hours.

Only yesterday I spent two hours strolling along a stream in New Jersey looking out for snakes while my oldest boy and a friend played in the stream. Together we found within a stone's throw of one another the shed skins of a common water snake, a milk snake, and five huge blacksnakes. I can tell by the scale patterns that each of the five large sloughs belonged to a different blacksnake. None of us saw hide nor hair of a snake, yet certainly several were near us. Incidents like this show how well snakes can conceal themselves and help us to understand how they live to shed many skins in spite of the array of enemies that surround them on land or in water or soar above them in the air.

12

WHERE SNAKES LIVE

AMONG SOME 2400 kinds of snakes alive on earth today it would be hard to find any two having exactly the same range, that is, inhabiting the same area of land or water. If you outlined in black on a huge map of the world the range of every known species you would be astonished to see the total lack of uniformity in size and shape of these ranges.

On land the distribution of the common viper of Europe and central Asia extends from the British Isles to the eastern shores of Asia; in the sea the yellow-bellied sea snake is found from the eastern coast of Africa across the Indian and Pacific Oceans to the western side of the Americas.

No other range compares to either of these two in size but there are species that inhabit extensive areas: The black-necked cobra, the puff-adder, and the famous egg-eating snake are distributed over vast areas from northern to southern Africa; in North America DeKay's snake is found from Maine to Minnesota, southward to northern Florida and through Texas to Vera Cruz in Mexico; the fer-de-lance of tropical America is met with from Bolivia to Mexico.

At the other extreme there are examples too numerous to name: Many small tropical islands have species peculiar to them; peninsulas are also more than apt to have kinds not found elsewhere. An interesting example of an island inhabitant is a strange boa confined to tiny Round Island, which is east of Africa and near Madagascar. Fully as interesting is the pit-viper that lives only on an island less than a square mile in area off the coast of southern Brazil. Birds are its sole available food, and this snake has developed an unusually strong poison enabling it to secure these agile creatures. Presumably, if the venom did not take effect quickly, a bird that had been struck might get beyond reach before dying.

In the United States there are several serpents with very limited distributions. The short-tailed snake lives only in Florida, and two or three other species are totally or nearly confined to that state. Small ranges of interior regions of the continents are also easy to find but one is often sure that they will be enormously enlarged with future explorations. The part of extreme western Texas lying south of New Mexico is the home of Baird's and Davis Mountains rat snakes and Davis Mountains king snakes. The ranges of these three snakes probably never will be greatly extended because the southwest has been well explored.

Now let us look again at our imaginary map of outlined ranges to see what else it shows. First, the Arctic, Antarctic, Atlantic, northern and extreme southern Pacific Oceans are entirely devoid of lines; second, on the continents none even approaches the Antarctic and only one crosses the Arctic Circle; third, few to no ranges are indicated in the great deserts and on the highest plateaus and mountains; fourth, the number of lines rapidly increases as the tropics are approached, the greatest array being seen in tropical regions with mountain chains of low to moderate heights.

Why are snakes so unevenly distributed over the globe? To understand their absence from extremely cold parts of the earth we have only to recall that they cannot maintain a temperature appreciably higher than that of their surroundings and that in regions of permanently frozen subsoil they would be unable to find suitable places for hibernation. Moreover, the warm season has to be long enough for mating and the development of young. The snake that ranges farthest north, the common viper of Europe and central Asia, sometimes mates before going into hibernation and gives birth to young in the spring. The advantages of this in a cold climate are obvious and may explain the survival of this species so far north.

The scarcity or total lack of snakes in very high mountains and on greatly elevated plateaus also is due to the low temperatures found in such places. Their almost universal presence in the tropics is merely the other side of their absence in the north, for the nearer they get to the equator the less they have to contend with low temperatures.

Putting aside this important question of temperature and coming to the parts of the earth where it no longer interferes with the existence of snakes, let us see what these reptiles have made of their opportunities. Have they, like the mammals, conquered the air, the land, and the water?

In the sea they have not done well. This is very surprising when we recall that a snake's form readily lends itself to easy graceful swimming. The entire Atlantic is devoid of them; fewer than three score species, or less than three percent of the known kinds, have made their home in the oceans. This is scarcely to be called a conquest. One small group, confined almost entirely to the East Indian region and known as river snakes, might be said to live between salt and fresh water. They frequent rivers and coastal waters, never venturing on land or going far to sea. The karung, an eastern snake severely persecuted by leather hunters, belongs to this group. It is so aquatic that Pieters kept specimens under water for twenty-four hours without hurting them and found that they even survived three days of uninterrupted submergence.

The fresh waters of swamps, ponds, lakes, creeks, and small rivers by no means are neglected, but the inhabitants of such places are usually only semi-aquatic and quite able to survive on land. Many of them, like the common water snake of the United States, thrive in captivity even when entirely deprived of all but drinking water. They enter that element for protection and generally find their best food supply in or near it. Commonly whole groups of related kinds inhabit water and its vicinity but some thoroughly terrestrial groups have aquatic relatives.

The African water cobra is a good example of this, other cobras being anything but aquatic. Loveridge found this species common along rocky parts of the shores of Lake Tanganyika, where he hunted them from a boat. The following is an account of the capture of a five-foot female that was spied just beyond reach of the breaking waves:

"It was impossible to get at the snake in its present position, which was quite a yard in, so I retired another yard and fired a charge of dust-shot from a .22 calibre collecting gun. This caused the reptile to squirm, coil, and uncoil. During these convolutions the tail came nearer and I slipped a leather noose over it, then started gently pulling till the tail was clear of the bowlder, when I handed the noose-stick to Salimu with instructions to go on pulling slowly while I covered the snake with my T-ended stick until its head should appear. At that very moment the snake came away with unexpected suddenness, Salimu, slipping on the wet bowlder on which he had been standing, nearly fell, had a sudden vision of the cobra's head raised a foot from the rocks, dropped his noose-stick and fled incontinently. As a matter of fact, there was nothing to worry about as I had pinned the snake about midbody with my T-stick, but it held its jaws wide open and Salimu thought that it was about to eject venom after the manner of its terrestrial relatives *Naja* and *Sepedon*. It distended its neck as it reared up, but the spread was only half as broad as that of a cobra of the same size."

Snakes have never been air-minded. In this they are like the amphibians but unlike certain fishes, many mammals, and, of course, nearly all birds. Among the living reptiles, turtles and crocodilians also have been satisfied to keep their feet on the ground but some lizards are good gliders. Having no arms or legs, snakes have kept their bellies to the ground and it may be this lack of limbs that has prevented them from taking to the air; nearly all flying or soaring vertebrates use limbs or similar appendages to support or propel themselves while in the air.

This talk of flight in reptiles is not just idle speculation. A whole group of flying ones with membranous wings much like those of bats lived on earth for perhaps a hundred million years. The remains of one kind that sometimes had a wing spread of twenty-five feet are found in fossil beds of Kansas. Life in those days must have been exciting but, alas! there was nobody to get excited since the last flying reptiles were decomposed or fossilized millions of years before the first man appeared.

Snakes would never win honors in an Alpine club because, as I have already said, high mountains are usually too cold for them. In warm or tropical climates they do, however, manage to attain good altitudes. In southern California Joseph Ewan found a Pacific rattlesnake only twenty feet from the mark recording the summit of Mount San Jacinto as 10,805 feet. The common viper of Europe and central Asia climbs the Alps in Europe to about 9000 feet above sea-level. Strauch's pit-viper reaches 13,500 feet in western China, and Dr. Harvey Bassler tells me that he has found snakes at an equal altitude in the Andes of South America. A few snakes, then, live almost as high as the top of Mount Whitney, whose height is exceeded by no other mountain in the United States proper. Mount Whitney in turn is approximately half as lofty as Mount Everest, whose summit looks down on the rest of the world from a point five and a half miles above the sea.

It is worth noting that all of these three snakes found at high altitudes are either true or pit-vipers and that all bear living young. The latter fact is of special interest because it may give a clue to at least one great advantage in bearing the young alive. The late Hazel Claire Weekes studied this problem in Europe and Australia and determined that as the country gets higher the egg-laying species drop out. She believed that this was due to the fact that the cold of high altitudes seriously interferes with the development of eggs. When the young remain inside the mother she can move about and control their temperature better than she could ever control that of eggs in a nest.

Although snakes do occur at great elevations, probably not one percent of all those alive today live even 5000 feet above the sea. On the other hand, the best snake countries are not low flat plains but regions of varied topography, mountains and plains mixed.

Nearly all species show preference for a particular type of country, be it level grassy areas, rough over-grown valleys, or forested mountains. Any special preference of this kind may be called a "habitat niche." Some very hardy species thrive in so many different habitats that they cannot be said to have special niches. The common garter snake is by no means rare in the great Okefenokee swamp of southeastern Georgia, and yet I recall finding several specimens sunning themselves 5900 feet above sea-level on the very top of Andrews Bald, one of the high forested mountains of the Great Smoky range lying between Tennessee and North Carolina.

It is really not so much the slope or elevation of the earth's surface that makes these different habitat niches as it is the effect that slope and elevation have on soil, vegetation, water, and other elements of the surface. Trees and lower plants invite arboreal species; a thick porous carpet of decaying leaves forms an ideal retreat for ground-dwelling kinds and good homes for burrowers. Other snakes prefer a zone intermediate between a heavy forest and open bushy or grassy country.

You can think of Nature as running a snake renting agency which tries to provide suitable niches for many scaly applicants. A slender vine-like species would ask for a great forest; a long but well-built kind would prefer fairly open hillsides where it could swiftly pursue prey and dash out of sight at the slightest sign of danger. Then might come highly polished iridescent applicants shaped like long sausages; they would surely be looking for an underground home. If they tapered toward the head, the middle of the body would forever be getting stuck in the hole made by the forward part, and their smooth shiny scales enable them to burrow through life with the least amount of friction.

Competition is very keen in this renting business because Nature lets room to too many comers and leaves them to settle among themselves the difficulties that arise over lack of enough food to go around and sufficient space for all. It is a free-for-all, catch-as-catch-can contest with absolutely no holds barred, but it has been going on such a long time that a sort of balance has been reached. The whole picture changes so slowly that only careful detailed studies will show us what is really happening. Each species has just three possibilities: its population is increasing, decreasing, or remaining constant.

Herpetologists have thus far spent most of their energy classifying snakes, so we know next to nothing about what is happening to the populations of even our common American species. It may be many years before a thorough study of the balance in a rich snake fauna is made. The problem is too complicated, what with dozens of species inhabiting the same region along with hundreds of kinds of other animals, not to mention fully as many plants. It is much better to start with a type of country at the other extreme, where few snakes occur and you have some hope of getting to the bottom of things.

Deserts are among the best places to choose for this purpose. The general uniformity of the environment there, the lack of thick vegetation, and the few species found make the problem relatively simple. Dr. Walter Mosauer, who has specialized in a study of desert reptile life, states that only three of our southwestern snakes are genuine desert animals although several others occur in such areas. All of the truly desert snakes show some sort of adaptation to their sand-bound lives.

The sidewinder, a rattlesnake, has developed the special method of traveling through sand (see chapter on locomotion and illustrations following page 76). The banded burrowing and Hallowell's ground snakes are able literally to swim in, as well as crawl on, sand, the former actually spending much of its time below the surface where it progresses quite as readily as on it. (See illustration facing page 105.) Both these snakes have wedge-shaped heads with counter-sunk lower jaws. The shape of the head enables them to burrow into the sand and the counter-sunk lower jaw prevents the sand from getting into their mouths. These heads are in strong contrast to the blunt rounded ones of burrowers in firm soil already referred to.

Wedge-shaped heads and special ways of getting about are really adaptations to life in a dry fluid medium like sand. But most deserts offer additional difficulties and obstructions to reptile life, chief among which is a high temperature combined with scarcity of shade and shelter. Even though many accounts of lizards and snakes basking or frolicking in desert sunshine are to be found, Dr. Mosauer proved by careful experiments that sidewinders cannot survive even nine minutes of October noonday sun in a sand dune area of southern California, nor could lizards do any better.

It is obvious, therefore, that desert species must avoid the heated sands and the direct rays of the sun in one way or another. Snakes are at a particular disadvantage because they cannot raise the body off the hot surface. Some lizards keep cool by standing on breeze-swept ridges with their bodies held as far as possible above the burning sand. Others climb into plants, a method that could of course be used by snakes. The latter, however, seem to avoid the heat by seeking shade, burying themselves, or taking refuge in some cavity or hole. Speed of movement is also an advantage obviating the danger of being killed if forced to cross a large open area of hot sand. Once the heat of the day is over, reptiles are free to move about, and this is why most desert species are nocturnal.

This analysis of desert conditions affecting reptile life is only a hint of what must be done to understand the snake life of any habitat. The question is complicated enough where only a few kinds are concerned; you can imagine what it would be in a tropical region inhabited by scores of species. This study of the relation of an animal to its environment is called ecology. No more fascinating subject exists.

The purpose of this chapter is to explain that when you find a snake in a particular spot it is not there just by chance. You will see what I mean if you start writing down just where you see each specimen of every species. After you have a score or more of records, a study of them will show you that each kind does have its favorite type or types of country. What I have written above is only the results of hundreds of comparisons of thousands of observations of the kind that you yourself can readily make.

13

HIBERNATION

IN THE fall of 1924 two men were caring for sheep in Snake Valley, White Pine County, Nevada, when they heard a noise like the swarming of bees. They soon found that this was being made by scores of rattlesnakes collected around a hole several feet across and ten feet deep.

About five years later Raymond Hall visited this den on May 22 and learned that the snakes already had been coming out for some twelve days. The local game warden told him that 139 rattlers had been shot recently by one party; no count had been made of the snakes that numerous other visitors had slaughtered. Piles of empty gun shells and carcasses in various stages of decay confirmed the warden's story. Dynamite had even been set off in the hole. In spite of all this Mr. Hall found every rock and bush within ten feet of the den sheltering its snake or snakes, each coiled, the head usually in the center of the coil. The hole itself held a good share of fifty rattlers seen by Mr. Hall. A careful search of the vicinity revealed only one individual more than forty feet from the den. The rattlers were still sluggish, many refusing to rattle even when prodded with a stick. Twenty-five specimens spared for scientific study measured from 11.2 inches to 3 feet 4 inches. All the snakes seen were the same kind, the Great Basin rattlesnake.

This den is located at the foot of a butte or low flat hill which stands out as the only irregularity in a level, non-rocky valley. The butte is composed of volcanic bowlders and wind-blown soil, the latter more or less filling the spaces between the rocks. The snakes used for their den a place at the northern base of the butte where the crevices had been incompletely filled. The isolation of this particular butte undoubtedly accounted for the unusually great number of snakes that gathered there.

Anyone could no doubt explore this den with perfect safety during the summer months, for only in the spring and fall are the snakes to be seen there in great numbers. Why is this so and why do snakes gather in such places at all? How do they find their way and do the same snakes return year after year to the same den? These are some of the questions that I shall try to answer.

Put yourself in the place of a snake with winter coming on. For the sake of being definite, let us say it is the fall of 1935 and you live in southern Montana. As the nights get more and more chilly you face the danger of dying of cold because you have no way of keeping your temperature more than a very little if any above that of your surroundings. Moreover, you find the frogs that you like to eat becoming scarcer and scarcer. An impulse makes you want to go down into the earth.

Of course, if you had wings you could join the birds and fly southward twelve hundred miles to a warm place. After all, though, it is so much easier to go a foot or two straight into the ground toward China than to travel over a thousand miles through the United States and into Mexico. No one knows exactly how much cold you can stand but it is known that certain lizards survive a cooling of two to three Fahrenheit degrees below the freezing point. You should be safe enough in a temperature as low as 32° F.

Plants and animals by living through millions of seasons have proved that the temperature of the soil does not change as rapidly or vary as much as that of the air. Therefore, in the summer the soil is cooler than the air and in the winter warmer. You do not know this but, obeying your impulse, you go down into the earth to remain until spring.

While you pass the winter thus safe and secure the human beings above you suffer from the coldest weather that Montana has seen for more than fifty years. Scientists make special studies and discover that while thermometers in the air register as low as minus 43.0° F. similar instruments buried four feet in the ground beneath eight to fifteen inches of snow go no lower than 33.8° F. above. You prove as much by emerging safe and sound in the spring, also from a depth of four feet. You do not know either that the thick white blanket of snow saved your life. The snow itself was not warm; it was the air held in its pores that kept much of the heat in the soil over you from escaping into the frigid atmosphere above.

This winter of 1935–1936 exposed you to as severe conditions as a snake would ever experience in North America. It might get colder in southern Canada but the deeper snow there would conserve the heat in the soil better. Snakes fear more than anything else a cold dry region where there is no thick white blanket under which to hibernate. If four feet is the greatest depth to which a snake would have to descend during the severest weather on record in one of the coldest parts of the United States, it is certain that the vast majority of American snakes do not have to go nearly so far down. Here are descriptions of a few actual sites:

On November 12, 1926, eight pilot black snakes, two blue racers, and a bull snake were found preparing to hibernate in a closed well. They were resting in the crevices of the rocks less than twelve feet below the surface of ground. This was in Kansas. The illustration facing page 112 shows a somewhat similar site.

In Utah, on March 15, a muskrat burrow sheltering thirty-five garter snakes was opened by a plow.

Eleven snakes of three species were unearthed by Hurter "while pulling out a rotten stump about 30 inches in the earth." This happened in Missouri on March 13.

In the fall of 1932 an old rat burrow on Long Island was found to harbor seventy-six DeKay's snakes, ten common garter snakes, and one common water snake. The burrow was only eleven inches deep. The following year numerous DeKay's snakes hibernated in this same vicinity at depths of six to thirty inches. (See illustrations facing pages 112 and 113.)

Near Stony Point, New York, eight timber rattlesnakes and twenty-one copperheads were dug out of crevices in rocky ledges. The twenty-nine snakes were encountered singly or in groups of two or three within an area twelve yards square and at distances of about four feet from the surface.

These descriptions show that depths of from a few inches through two and a half feet give ample protection in most cases. They also convince one that the rattlesnake den described at the beginning of this chapter is a most unusual kind of hibernation site. In fact, few persons ever see such a nightmare of snakes even though stories of dens abound everywhere. Many tales persist long after the reptiles that started them have passed into the snake beyond.

It is hard to say how often individual snakes spend the winter alone because the discovery of a single one attracts little attention whereas the unearthing of a coiled mass of them is an experience not easily forgotten. It is certain that hibernating in groups is a common enough habit.

Whatever its advantages certain disadvantages are evident: By coming together the snakes expose themselves to attacks of animals, especially man. The slaughter at the Nevada den is as good an example as one needs. Although I can find no actual accounts of other animals killing great numbers under similar conditions, it is certain that many bird and mammal enemies frequently do just this. Also, how convenient it must be for a snake-eating snake to hibernate with species that it likes to eat. It would be assured of a full stomach to hibernate on.

In a region where suitable places are scarce and snakes numerous, the advantages of mass hibernation are obvious. Noble and Clausen found that DeKay's snakes readily follow trails left by other members of the same species and this explains how they are able to gather at dens. The sense of smell is chiefly used in following trails. Experiments showed that the scent left by the snake being trailed comes from its skin. Here is an unexpected advantage of a good long contact with the ground—crawling along a single narrow line leaves the best possible trail.

Still more complicated experiments proved that snakes twined closely together lose water through the breath and skin more slowly than lone individuals. This saving of water is especially necessary for any group exposed to a dangerous combination of dryness and heat but may not be so useful under the cooler conditions of hibernation.

During the hot summer months snakes ordinarily avoid the direct rays of the midday sun. In the fall, on the other hand, they hunt for southern exposures of hills and valleys where its weakening rays will warm them during the day long after the nights have grown chilly.

Rocky places are often chosen because there crevices and holes are sure to be numerous. In the spring they come out to bask in sunny spots of the same ledges that were used in the fall. As soon as the nights have lost their chill they scatter far and wide. In short, the spring finds each one doing the reverse of what it did the previous fall.

It is impossible to say how often snakes return to their old winter quarters. The DeKay's snakes studied by Noble and Clausen did not show a marked tendency to do this. It is probably largely a matter of chance; where suitable holes and crevices are numerous, few returns would be expected. This question can be answered fully only after the movements of hundreds of marked snakes have been watched year after year.

You now know a good deal about snakes in winter but I have not told you much about hibernation itself. No one can say exactly what it is, but we do know that it produces an insensibility far deeper than sleep. In spite of this, hibernating animals become aroused if warmed or disturbed. Hibernation serves to tide the animal over the cold and famine of winter. A similar state known as æstivation enables it to survive dangerous periods of dry heat. The avoidance of low temperatures is so necessary for reptiles that it seems to be the chief factor with them. To mammals the question of food shortage is more important.

A hibernating animal of any kind is conserving its strength by living at a much slower rate than usual. This enables it to get along on the fuel, largely fat, already stored in its body. Actually several months without food during hibernation strains it much less than as many months of ordinary living on an empty stomach. What is five months of hibernation to an animal that is able to go hungry three times that long while wide awake! One of Benedict's pythons fasted nearly seventeen months at temperatures too high for hibernation and was reduced to half its weight. At the end of the first five months, however, it had lost only a twelfth of its weight.

I know of no extensive studies of hibernating snakes, but keepers of these reptiles who have measured their specimens before and after a period of hibernation in captivity have been surprised to find a very small loss of weight; increases have even been noted. The latter were probably due to absorption of water or drinking.

For example, to study hibernation of the horn snake, in Louisiana, George P. Meade nearly filled a packing case measuring 30 x 30 x 36 inches with alternate layers of mud and leaves and buried it near a small pond, placing its bottom at the level of the water in the pond. One end of the box was left empty to allow passage up and down and many small holes were bored in the sides to admit water. After the horn snake had been placed inside, the packing case was covered with heavy wire screening and sheet iron. The snake, when put in these artificial winter quarters on November 4, measured 65 inches and weighed 3 pounds 11 ounces. The coldest weather of the winter was on January 21, the thermometer then registering 20° F.

The snake did not appear until February 14, when it was found on the surface. It again disappeared and was next seen on March 6. It had lost but one ounce and seemed to be in good condition. After more periods of concealment it was finally dug out on March 26 from a pocket of wet leaves at the bottom of the box, apparently where it had spent the winter. It ate readily after its fast of five months and twenty-two days.

The layers of mud and leaves used in this experiment reproduced very nearly the normal habitat of this secretive snake. In making such a study the more records of temperature taken both in and out the box the better. The temperature of the snake may be considered the same as that of its immediate surroundings.

It has been said that the poison of hibernating snakes is not so dangerous as that made during periods of normal activity. Some have even tried to show that secretion of venom ceases during winter sleep and that the poison glands are then empty. An experience of my friend Carl F. Kauffeld, however, showed to the satisfaction of everyone that a snake may be as poisonous while hibernating as at any other time.

During a warm spell in January, Mr. Kauffeld and others were looking for specimens, chiefly copperheads and timber rattlesnakes, which had been disturbed in their winter quarters by road construction near

Nyack, New York. The snakes were found singly rather than in groups and the temperature in the rocks where they were taken stood near 50° F. This probably explains their unusual activity. The collectors worked by shifting loose pieces of rock until snakes were sighted. These were then extracted in the best way possible and placed in bags.

In a desperate effort to land a fine copperhead, Kauffeld seized a tail rapidly disappearing under a rock. The owner of this tail, instead of going deeper and deeper under the rock, crawled around and managed to free its head, which, however, was hidden from Kauffeld's view by a projecting ledge. After a few moments the snake succeeded in biting its captor on the right thumb at the base of the nail. Only one fang entered the flesh. The rapid swelling of the hand accompanied by discoloration proved that the poison was strong enough to have done serious damage if sufficient quantity had been injected.

14

POPULAR BELIEFS

AT THE age of ten I kept my pet snakes in a play house that happened to be in full view from the window of my grandmother's room. The play house no longer attracted my older sister and brother, so they had turned it over to me to use as a miniature reptile house. Because of its small size, my legs always stuck out the door while I lay on my stomach watching a king snake devour a water snake or trying to persuade some obstinate pet to eat. Time flew by whenever I was playing thus and often my legs remained quite motionless for an hour or more at a time.

Although my grandmother kept her shutters drawn, I could literally feel her anxious gaze as she looked through them for minutes at a time fully convinced that my life was in great danger and wondering how she could get me out of the spell that those terrible creatures were holding me under. To her it was a clear case and proved beyond doubt what powers snakes have over human beings. She could not explain just how I survived the frequent spells cast by the snakes and always believed that sooner or later I should meet a terrible end. Explaining to her the harmlessness of my pets was useless. My grandmother was not a superstitious or credulous person; she only shared the current belief of her generation that snakes can charm both man and beast.

Many people, I think, will smile at my grandmother's fear that the snakes were casting a spell over me but believe at the same time that a snake can charm a bird. There is no more reason to give credence to one belief than to the other; both survive from a time when it was generally believed that one animal had psychic control over another.

The next step beyond this is the idea that animals either directly or indirectly control the forces of nature. Such ideas are held to by so-called primitive peoples the world over and result in elaborate ceremonies or rituals to please or propitiate the animals concerned. The advantages in trying to "keep on the good side" of anything having supernatural powers are too obvious to dwell on.

The Hopi Snake Dance is a fine example of the important place that snakes may occupy in the lives of human beings. Everyone interested in snakes is indebted to L. M. Klauber for his study of this ceremony from a herpetologist's point of view.

He tells how every summer at a carefully determined time, the Hopi or Moqui Indians of Arizona go out in the country surrounding their villages and hunt snakes with persistence and energy until they have brought together a large catch which always includes many dangerous rattlers. These snakes, sometimes numbering a hundred or more, are placed in sacred clay jars stored in an underground or semi-underground vault, the kiva, where men, known as snake priests, spend many days making prayer sticks and special costumes and performing various sacred rituals. On a certain day the snakes are removed to the kisi, which is a tepee-shaped structure temporarily erected on the village plaza.

After sundown of this day, before the assembled village and many visitors, the snake priests, in groups of three, begin to dance with a shuffling step around the plaza. As each group passes in front of the kisi, the leader, known as the "carrier," stoops, and is handed a snake from within. He puts the snake in his mouth, holding it between his teeth at a point a few inches from the head, and continues his shuffling gait still accompanied by the other two members of his trio. After dancing a short time with a snake, it is passed to the last man of the trio and another is received by the leader. Trio follows trio until there is a circle of dancing priests, some receiving, others putting down snakes. As the snakes accumulate they are handed out of the circle of dancing priests, to other nearby priests who have been busy all the while furnishing rhythm for the dance with chants and rattles.

After all the snakes have been danced with and most of them passed out to the chanting priests, a space is outlined on the ground with cornmeal and the snakes piled on it. The snake priests now rush to this space, fill their hands from the seething mass, and run off to the north, south, east, and west, onto the plain below the village, where all the snakes are turned loose.

This dance may sound like the behavior of madmen but in reality it is carried out with deep feeling and dignity, and attention is paid to every detail year after year. Moreover, it is only one of a long series of religious ceremonials lasting many days. The Hopi do not worship the snakes but believe that they carry prayers for rain from the priests to the rain gods, which are underworld gods. The association between the snakes and rain seems to be: rain—lightning—sinuous shape—snake. In a predominantly arid country, the brief rains are absolutely necessary for the growing of crops, and so in the Hopi mind the snake messengers are quite as important as trucks, trains, and boats are to us; without such means of transportation lack of rain year after year would often spell starvation to large numbers of our population.

In China the salamander, not the snake, is thought to control the rainfall. At one locality I was advised to be cautious about collecting salamanders during a long dry spell. My Chinese friends feared that the farmers might believe that I had annoyed the salamanders and caused them to hold up the rains. The thoroughly aquatic habits of some salamanders are partly responsible for this belief in their power to influence the weather.

In spite of the fact that science has rid us of innumerable superstitions concerning the supernatural powers of animals, we still cling to a surprising number of ridiculous beliefs about snakes especially. We are all the more to blame because we should know better. Are not our libraries full of trustworthy books on every subject?

When a farmer insists that his sixteen-quart cow has fallen off a quart a day because of the theft of her milk by a 30-inch milk snake, he is accusing the snake of consuming about eight times its own volume of food every twenty-four hours! This is easily proved by measuring the amount of liquid displaced by a 30-inch milk snake, a very simple experiment (illustrated facing page 104). The volume of a large 37-inch snake of this species is only half a pint. Snakes are well known to eat big meals but not that big! Here are a few other reasons why a milk snake could not perform such a feat:

Unless it carried its own milking stool, it could not reach the cow's udder. If wrapped tightly around the cow's leg near her udder the snake would obviously be unable to force much milk into its body.

There are no sucking muscles in its throat that would enable it to get the milk out, for milking a cow is no simple task as every milker knows. Nor are there any valves or sphincters in its throat to keep the milk in under pressure of the distended stomach, body-wall, and skin.

The six rows of sharp teeth in its mouth would not tend to soothe the cow; on the contrary the pain would drive her frantic.

The milk-sucking story is a good example of a myth without foundation. It is true that the milk snake of the northeastern United States frequents the vicinity of barns and stables; its presence there is due to its appetite for mice and baby rats, which it consumes in great numbers. It should therefore be protected, not persecuted, by farmers.

The equally popular "hoop snake" story is almost without a basis of fact. This famous creature is supposed to take its tail in its mouth and roll downhill like a hoop. Moreover, it has a sting in the end of the tail so deadly that even trees quickly wither and die when stung. The very thought of a hoop snake strikes terror in the believer's heart.

Although two large, brilliantly colored, secretive snakes of the southeastern United States are identified as the hoop snake, neither of them rolls like a hoop nor has a sting in its tail. In fact no snake possesses such a weapon. One of these "hoop snakes" is more accurately known as the rainbow snake, the other as the horn snake. Both have a sharp scale ending the tail and a habit of harmlessly pressing this scale into a restraining hand or arm. What a feeble basis for the alleged behavior of the mythical hoop snake! The late John K. Strecker, our greatest authority on the reptiles and amphibians of Texas, states that the horn snake uses this terminal scale in working the slippery siren or "mud eel," on which it feeds, into position for swallowing.

Parts of Borneo are so low and level that they are flooded during certain seasons. At such times one may wade through a rain-forest for miles on end. Now, about the middle of a hot day, several weary rubber hunters chanced upon a large log in the water of a flooded part of this East Indian island and decided to cook their noonday rice on this log. Meals to these people are simple affairs; in a few minutes a small fire had been started under the cooking vessel. The men squatted along the log to wait for the water to boil. A more impatient member of the group raised his ax to cut a chip from the log to add to the fire. His ax came down with a thud and a chip came up. But, lo and behold! the place from which the chip had come began to bleed! Only the chopper had time to see this for the whole party was immediately sent sprawling into the mud and water by the agonized writhing of the huge python.

Harry Raven brought this tale back with him from Borneo, where it was frequently told to him. Of course no python grows to be the size implied and I am sure you can think of other reasons why it should be classed with the milk and hoop snake fables.

Most common beliefs, in contrast to those just related, have a basis of fact and indeed the snake itself is often partly responsible. When a hog-nosed snake—popularly known as "spreading adder" or "blowing viper" —flattens its neck, hisses, and in other ways makes itself look dangerous, it is certainly to blame for its bad reputation. Who would be so bold as to observe it closely enough to see that it never actually bites and generally jabs with tightly shut jaws? Even the breath of this perfectly harmless creature is supposed to be poisonous. Its behavior is described in more detail in the previous chapter on defense.

The "joint" or "glass snake," though not a snake but a legless lizard, is so commonly thought of as a snake that it must be included here. This reptile, like many other lizards, is about two-thirds tail and not only survives the loss of this astonishingly long tail but can grow a new one. Moreover, this tail is so fragile that a light blow or two will apparently break the whole animal into several pieces. One of these (the body) must of course equal at least a third of the original total length. The sections resulting from the "shattering" of the actual tail may be of any length. They wriggle and move for a short while, and this has undoubtedly led careless observers to conclude that the broken creature re-assembles itself. The version that each piece grows into a whole new snake is also understandable. The behavior of the reptile has again misled those not too anxious to discover the truth.

A few beliefs are nothing more than wrongly applied rules. For example, the common statement that a poisonous snake can be told by the shape of its head may well be true in places where the only dangerous snakes have broad heads, the only harmless ones, heads no wider than the necks supporting them. Such places are unfortunately rare. Also the terms broad and narrow are entirely relative. This rule would be of some use in approximately the northern two-thirds of the United States, that is, the part north of the range of the poisonous narrow-headed coral snakes.

One fault of the rule is that it would cause trouble to people and broad-headed harmless snakes alike. The former would be frightened by the latter and the latter needlessly killed by the former. The other and greatest fault is that one can more easily learn to recognize the relatively few poisonous snakes of the United States than one can learn to apply the rule. In tropical South America, tropical Africa, the East Indies, and tropical Asia this rule would be dangerous; in Australia, where elapid snakes, relatives of the deadly cobras and coral snakes, predominate, it would be ridiculous.

Of all beliefs about snakes I know of none that illustrates better the difficulty of deciding between truth and fiction than the mother-snake-swallowing-young-for-protection story. Some herpetologists would include it in a chapter on habits. There are hundreds of references to this tale in the literature of folk-lore as well as in that of herpetology. The story itself is evident from its title—accounts differ only in minor details. Scientists and laymen of unquestioned veracity have witnessed the act, so how can one doubt it? The four chief reasons why I doubt it are:

Snakes are well known to take little or no interest in their young.

No such act has to my knowledge ever been witnessed in one of the large zoos or museums of the world; nor do I know of any person who has seen the act repeatedly performed by a captive snake.

There are many plausible explanations of how such a belief might have originated.

I know no herpetologist who has actually seen it happen.

The most plausible explanation of a possible origin is the fact that many snakes give birth to living young and these young survive if their mother is cut open a few days before time for their normal birth. Snakes are often killed with brutal enough violence to set free any well-developed young. The common ophidian habit of eating other snakes or even young of their own species might easily mislead anyone who did not know much about the different kinds found in any one region.

It is very hard for me to keep an open mind in considering this famous story. I am all too strongly inclined to maintain that people have only seen what they expected to see. The late John K. Strecker describes a little incident that illustrates what I mean:

"A captive rattlesnake gave birth to a number of young. When the attendant and I approached the cage, the young snakes had all disappeared. The attendant immediately asked, 'Do you suppose that she swallowed them?' I shook my head negatively and a few moments later the little snakes were found widely scattered—they had escaped through a crack in the bottom of the cage and were lurking in the grass at the back of it."

Most of the beliefs described and discussed above are mere superstitions, not real myths. In the past, so few have been written down that all are difficult to trace to their birthplaces. Many have not been studied by ethnologists; some are so old, have traveled so far, and have been believed by so many peoples, that their places of origin are forever lost. Others are easily tracked to their original homes. For example, the snake cult of Haiti undoubtedly was brought from Africa by slaves and certainly many a superstition of the southeastern United States also came from Africa.

Only ethnologists are trained to make really scientific studies of superstitions and myths, but any one of us can study snake stories in a modest way by simply asking farmers questions about snakes. Then those who are fortunate enough to travel widely can continue their studies by doing the same thing wherever they go.

Most herpetologists are interested in false beliefs about snakes chiefly because of a desire to abolish such beliefs. This is largely the point of view reflected here, but I do not mean to imply that the myths and stories are not in themselves interesting and worthy of independent study. This is especially true of real myths, many of which are far enough from actual fact to be harmless.

Superstitions often require a definite object on which to fix themselves. In China there is a so-called "glass snake" (shown in illustration facing page 104) very much like the one found in the United States and with it somewhat the same belief about its ability to live after being broken into many "pieces." Such a belief probably would not exist where there is no "glass snake" on which it could be fixed.

I learned many years ago that teaching people the truth about snakes is not always a pleasant task. It is best to use great tact and never bluntly deny the possibility of some "tall" tale. You will often find that a father or mother made the observation, and a denial will be taken as a personal matter or even an insult. I recall enraging my closest friend by maintaining that the so-called "spreading adder" is harmless. It turned out that his father had told him it was harmful, and his father could not lie.

A friend may be of more value to you than his ideas about snakes, so it may be well to ask first: "Why do you believe that a milk snake sucks cows," or "that a snake is as slimy as an eel?" Then, as soon as you have sounded the depths of his belief, you can explain to him as diplomatically as you judge necessary why it is impossible for a milk snake to suck a cow or that a snake is really not slimy.

15

SNAKES AS MEDICINE

Sometime when you are sick but not sick enough to have lost your sense of humor you might while away the hours by trying to imagine what treatment you would receive if you were ill at different times and places on the earth. For example, if you were a Jacalteca Maya of western Guatemala, Central America, and caught a cold, your parents would treat it with hot snake fat wrapped in tobacco leaves. In China you would certainly not get in the habit of crying after going to bed because children who cry in the night are sometimes given powdered viper eyeballs in a bamboo decoction.

Guatemala and China seem far away, so let us come nearer home. You may be surprised to learn that as we approach home the remedies become more complex. If you had been so unfortunate as to contract scurvy in England two hundred years ago, they would have fed you daily on "viper bread" made by the following directions:

"Take powder of viper's flesh, 1 ounce; the mealy part of sarsaparilla finely powdered, 3 ounces; fine wheat-flower, 1 pound; yolk of an egg, a little yeast, and as much as is sufficient of milk to make cakes, or loaves, to be baked in an oven."

Or, if the doctor had decided that you needed to sweat, he would have prescribed "compound tincture of vipers" made as follows:

"Take of Flowers of Sulphur one pound, crude antimony 4 ounces; grind them to a fine powder; put it into an earthen dish; and saturate it with Oil of Sulphur, made by the bell (or oil of Vitriol) 4 ounces; put it into a retort, and pour gradually upon it of sweet Spirit of Nitre 1 pound: place the retort in a sand-furnace, and draw off the Spirit. Into 1 pound of this Spirit put two ounces of dried Vipers (cut into small pieces) let them digest forty-eight hours in a matrass; when cool strain it through an hair-cloth. Return the menstruum into a matrass, adding of Cochineal, Saffron, and Virginia Snake-root, ana 2 drams: let them digest forty-eight hours; then decant the clear Tincture."

This tincture "was much used with success" in the London plague of 1665. The dose prescribed was "from 10 to 50 or 60 drops in Canary or Plague-water."

Even though viper bread and compound tincture of vipers are fairly complex mixtures we have yet to describe the most heterogeneous as well as the most famous concoction of all. This was called "treacle" or "theriaca" and, as a matter of fact, is still known by these names for it is used today as a home remedy in parts of Europe. (It has nothing to do with the syrup that is known as treacle in the United States.) Treacle was first described in a book written during the second century B.C. It was supposed to be an antidote for bites of poisonous animals. The most famous kind of treacle was invented by Andromachus, physician to Nero in the first century A.D. Andromachus named it "Galene" and included vipers among its seventy-three ingredients. He claimed that it would "counteract all poisons and bites of venomous animals, and that it would also relieve all pains, weakness of the stomach, asthma, difficulty of breathing, phthisis, colic, jaundice, dropsey, weakness of sight, inflammation of the bladder and kidneys and the plague."

Treacle reached its height of popularity in the sixteenth century, when it was widely used over Europe and a formula of 250 ingredients was published. Its popularity slowly waned and the number of things put in it decreased, but in England it appeared in official pharmacopœias until 1746. In France it survived as an official remedy through the nineteenth century, but in 1884 vipers were dropped from the list of ingredients. You can imagine how many vipers were sacrificed in the manufacture of treacle when I tell you that more than a ton of it was mixed at one time in Paris during the year 1702. So great was the bulk of this mixture that a special jar had to be made to hold it.

If you want to learn more about this most remarkable and perhaps most ridiculous of medicines, read pages 58 through 66 of C. J. S. Thompson's fascinating book *The Mystery and Art of the Apothecary.*

It is not surprising that the official use of treacle survived so long in

France when we learn that vipers have always been valued as a medicine and restorative in that country. This is well illustrated by the fact that a certain French book on old remedies devotes about forty pages to the viper. In the year 1685 the famous letter writer Madame de Sévigné wrote of vipers as follows:

"They temper, purify, and refresh the blood. But real flesh must be used, not the powder. Ask M. de Boissy to send you ten dozen vipers from Poitou, three or four only in each box so they may travel in comfort, packed in moss or sawdust. Then take a couple every morning, cut off the heads, have them skinned and chopped up and stuffed in a chicken. Do this for a month, and then blame your brother if M. de Grignan does not become as well as we could wish him to be."

Although the Europeans excelled in the number and diversity of ingredients included in medicinal concoctions they seem to have found use for few snakes save the vipers. The Chinese, on the other hand, showed woeful lack of imagination in making complex mixtures but were far ahead of our ancestors in the number of snakes used and the variety of remedies made from them. I often amused myself in China by stopping at medicine shops and asking for snake cures. Nor do I remember being disappointed. In one place I was accused by the villagers of paying smaller sums for a certain kind of pit-viper than the native catchers always paid on their yearly visits. The native catchers of course secured snakes for the medicine shops.

Dr. Bernard Read has found that the following parts of snakes are valued by the Chinese: slough, skin, bile, flesh, fat and oil, head, eyeballs, eggs, and bones. Some of the diseases and afflictions treated are convulsions, insanity, epilepsy, colds, poor sight, malaria, sore throat, earache, toothache, deafness, rheumatism, and arthritis. Dr. Read lists seventeen kinds of snakes that fall victim to the medicine man but undoubtedly many more are used.

I think it is only fair to give the Chinese credit for the most far-fetched idea when they include in their materia medica rats and frogs swallowed by snakes. Perhaps here after all is the basis of the widespread belief that house rats are eaten in China! I am at a loss to know what to say about the deadly snake that first bites and then climbs a tree to advise its victim. If it says: "*Ch'e mu, ch'e mu,*" the bite will be fatal, but if it says: "*Po shu, po shu,*" the bite can be cured!

Just as the use of snakes all but disappeared in Europe during the nineteenth century, so it is rapidly decreasing in China before the advance of western science and medicine.

Many people would be surprised to learn that I am frequently asked questions about rattlesnake oil as a cure for rheumatism. Some want to know how to extract it; others, what price it brings. Most of those who write me about it seem to take its medicinal value for granted, and I know one concern that includes it for sale as a by-product of the snake-leather novelty industry. So you see, we do not have to go out of the United States to encounter the use of snakes as medicine nor do we have to go back to the past centuries. It is only fair to state, however, that I have never heard of any part of snakes except oil and fat being employed in the United States today. I except the perfectly legitimate use of the venom in very small doses, a subject that has been treated in the chapter on usefulness of snakes.

In order to be absolutely sure that I make no mistake in telling those who ask about snake oil that it is entirely discredited by modern medicine, I recently wrote to the American Medical Association. Their reply, dated March 25, 1936, leaves no room for doubt. The final paragraph reads:

"There was some excuse for the Indians, in their ignorance, using rattlesnake oil. There is no excuse for its continued sale in a presumably intelligent nation."

However, I am told that the dispensers of snake oil are sometimes aware of its uselessness but maintain that when sold at a high price it has value because the purchaser will rub it in well and derive real benefit from the rubbing. Their convenient wisdom is: cheap, little rub, no good; expensive, much rub, much good.

From what has already been said it is evident that the white man included snakes in his materia medica long before he came in contact with the American Indian but, in spite of this, it is possible that the early settlers were taught to apply snake oil to rheumatic limbs by the Indians. Already believing in the curative powers of snakes, the ignorant settler would have been easily influenced to add another disease to his already long list of those cured by snakes.

It is highly improbable that one Indian ever tried to cheat another by selling him imitation oil, yet this is apparently done to this day by "civilized" white men. About twenty years ago federal authorities seized 51 bottles of "White Eagle Indian Rattlesnake Oil Liniment" that proved to contain little if any snake oil. The liniment had been advertised to cure rheumatism and other ailments. Judgment was passed on October 16, 1916. Think of it, faking a medicine that is itself worthless!

Books written about the United States during the two preceding centuries frequently mention belief in the curative properties of snake meat and fat. The fact that the value of the rattlesnake was sometimes compared to that of the viper is good evidence that the rattler was merely being substituted for the viper by those already familiar with the latter in the "old country." Surely the Indians must have learned more of the supposed curative powers of snakes from the white man than the white man from the Indian.

16

SNAKE HUNTING

It goes without saying that my own children are taught when very young to hunt snakes. One of my boys at the age of three was out with me on an over-grown mill dam site in New Jersey. Suddenly he pointed, saying:

"Daddy, there's a 'nake."

I followed the line of his finger and saw a large blacksnake under the remains of an old board walk. I had passed almost over it and had to retrace my steps to its hiding place. Lying down so that I could reach under the boards, I was startled by an unexpected jab that the snake, suddenly aroused, made at my face. The quick movement of my head threw my cap off and Hal said:

"Oh, Daddy, did the 'nake knock your hat off?"

Of course, this snake was too much for a youngster of three to catch but there are smaller kinds that can be hunted with some success at such an age.

It is not fair to state that snake-hunting is dangerous any more than it is fair to say that hunting furred animals is dangerous. Whereas with furred animals or mammals the danger increases with the size of the mammals hunted, with snakes the danger depends entirely on whether the country hunted in harbors poisonous species. No snake is dangerous in any real sense simply because it is large. In fact, the large snakes are notoriously docile and gentle.

The reticulate python, probably the largest snake in the world, has a very timid disposition. On a certain occasion recorded by Colonel Wall, a noted authority on Asiatic snakes, several men found one of these pythons in a jungle. It lay motionless even after being surrounded and was easily killed by one of the men who walked up and cut its neck with a sharp weapon. All of five other reticulate pythons encountered in Burma and reported by Wall behaved in the same way. The largest snake of Africa, the rock python, though less docile than the Asiatic snake just referred to, is not really dangerous. The following account of the recapture of a twelve-foot specimen by Arthur Loveridge illustrates this point:

"Shortly after midnight on September 20th, I was roused from sleep by an orderly inquiring politely if I wanted a fine big snake. Of course I did, and hurriedly donning socks and slippers I accompanied him. . . . The man led me a few hundred yards up the road and on the way we passed a broad track in the dust which suggested to me for the first time that my pet might once again have strayed from home. Our destination was the mess marquee of the sick officers' wards of the 15th Stationary Hospital. As we entered, with no light beyond that given by a somewhat feeble hurricane lantern carried by my companion, I saw a python lying beneath the table. As I approached he lunged at me a couple of times with widely gaping jaws then began to retire as I made a detour of the table to approach him. I seized him by the neck just as the orderly, placing the lantern on the floor, went off in answer to a call. For fully two minutes I struggled with the creature, slipping his coils off my arm before he tightened them; having my foot upon his tail gave me an advantage and as soon as I got his head into a sack there was no further trouble. As a rule, when once shown a way, a python will readily slide into the darkness and fancied security of a sack."

Although this snake is referred to as a "pet" it was not tame, having been in Mr. Loveridge's possession but eight days. It had been retaken by him with no more difficulty six days before. I believe that a strong man can capture single-handed a python of even much greater size.

Just as surely as hunting harmless snakes is a perfectly safe pastime or pursuit, hunting poisonous ones is very dangerous. The danger lies not so much in the hunt as in the capture. While actually looking for snakes one is not likely to step on them, but catching a venomous species has the same potential danger that exists in the handling of firearms. I do not advise the catching or keeping of highly poisonous species by amateurs and certainly no boy or girl should be allowed to hunt, catch, or keep them.

Many people will say to this: "Yes, but how can you separate the hunting of venomous from the hunting of harmless kinds?" The answer has two parts. First, if you are out looking for snakes you can easily avoid or kill any dangerous ones found. Secondly, snakes are often locally distributed and there are numerous areas quite devoid of poisonous kinds. Long Island is a good example of this in New York State. The copperhead and timber rattlesnake are of course well known in Connecticut, New Jersey, and other parts of New York.

In fact I believe that, acre by acre, not one acre in five of this country harbors a single snake whose bite is commonly fatal to man and that not one acre in twenty-five conceals individuals of more than one deadly species. It is only fair to remark, however, that taking the state as a unit, Michigan alone can boast of being entirely free of *deadly* poisonous snakes, the only poisonous kind found there being the massasauga.

Information about the presence of poisonous species in any region can generally be obtained from books, naturalists, state or local museums, or the more intelligent old residents. It is best to get such information from at least two sources.

The long and short of this whole question is that we must use our intelligence, not our emotions, in deciding what chances there are of encountering dangerous snakes in any given place. I know a lady who, though an ardent lover of nature, has never dared to walk across open fields because of a dread of stepping on a poisonous snake, and yet no poisonous kinds exist in the vicinity of her home!

We cross the streets alone from the age of three or four up and yet death lies in the careless crossing of a street. Surely we can learn about the danger from snakes and avoid it, just as we avoid speeding automobiles. The only difference lies in our point of view of these two dangers: the one we understand harbors no dread and we take chances in crossing busy thoroughfares, being scarcely conscious of the narrow escapes experienced so often; snakes we generally do not understand and we therefore fear them or become alarmed at the sight of one although it is well known that none of our native snakes attacks man. Very few snakes of any part of the world do this. In the United States the problem of learning to recognize the poisonous species is especially simple, as the following statements show:

There is only one generally distributed group of dangerous snakes—the rattlesnakes—and all of the many species of this group bear a telltale rattle. In addition there are: the copperhead, widely distributed in the eastern and south-central states; the water moccasin, of the southern states westward to Texas; and two species of coral snakes, also found only in southern parts of the country. The differences between these snakes are explained in the Appendix, where their exact ranges are also given.

Dr. Raymond L. Ditmars, the most widely known American authority on snakes, went to Central America to study and collect bushmasters. After tramping through tropical jungles for about two weeks without seeing a snake of any kind, Dr. Ditmars decided to return to New York. He did not, however, sail from Central America entirely empty-handed, for, barely having thrown off his coat on the steamer, he was called to the door of his cabin by a knock. When he opened the door a steward said:

"Can you come to the doctor's cabin, at once, sir?"

"What is the matter?" asked Dr. Ditmars.

"There's a snake among his books, sir. The doctor doesn't know what kind it is." [1]

Dr. Ditmars went with the steward to find an infant boa constrictor crawling over the doctor's books! The snake had escaped from a glass jar in which it had been brought to the doctor as a present. Twining the boa about his hand Ditmars confessed that this was the first snake he had seen since arriving in Central America two weeks before.

This incident graphically illustrates the common experience of all who have hunted snakes in tropical forests. I recall looking in vain for specimens in the jungles of British Guiana. In fact, the discovery of a snake was always considered a rare event by anyone in our party. It is generally believed that tropical forests are fairly alive with snakes, and many a tourist has carefully avoided entering jungle growth for fear of meeting them. Moreover, lists always show that at least twice as many species occur in tropical regions as in temperate ones of equal area.

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[1] Reprinted by permission from *Confessions of a Scientist* by Raymond L. Ditmars, published by the Macmillan Co.

Why, then, is it so hard to find snakes in the tropics, especially in jungles? The explanation is twofold: Although greater numbers of species exist in the tropics, there are fewer individuals of each species; and the more luxuriant growth of tropical vegetation affords vastly better hiding places for the individuals inhabiting it. Those of us living far from the equator, provided we are not too far north or south, have about as good an opportunity to hunt snakes as anyone living within the tropics.

There are many other places besides tropical forests where snakes are hard to find. These animals have a most discouraging way of concealing themselves. They are so secretive by nature that it is well to develop the habit of looking under objects—stones, boards, logs, piles of leaves, brush, or grass. If several persons are together on a hunt, they should spread out so that each one will be sure to turn over objects untouched by the others. Sometimes it is well to surround a likely-looking field or woodland and work in toward the center. In this way any large snakes will be trapped. A group of collectors can investigate literally thousands of possible hiding places in the course of an afternoon.

When all is said and done, the only really efficient way to find snakes is to learn the habitat choice of each species and then search diligently in that habitat. As a boy in northeastern Georgia, I could never be sure of catching even one snake in a day's hunt until I learned to wade up small streams while a good warm sun was shining. Then and only then could I be sure of securing from four to eight snakes in a day. Two kinds of semi-aquatic snakes, the queen snake and the common water snake, come out to lie on logs or brush piles in the streams, or stretch along bushes or branches of trees extending out over the water. By wading quietly *upstream* I could either pick them off before they had taken alarm or chase them to some place of concealment whence I could pull them with my hands. (See illustrations facing page 133.) The human hand is the best of snake grabbers in a place where no poisonous snakes occur or for one who unquestionably knows his snakes.

In contrast to this stream hunting, Walter Mosauer found that he could track specimens in the sands of a California desert and in 1932 discovered from tracks that the prettily banded tricolor Hallowell's snake is really common though formerly considered rare. He learned to distinguish the various species inhabiting the desert by the forms of their tracks. One snake was caught at night after being tracked for 200 feet.

In fact, the night is the only good time to catch certain snakes. I recall how puzzled I was at being unable to find a species of green pit-viper inhabiting the mountains of southern China. These green reptiles, sometimes called "bamboo snakes," were brought to me by the local people in great numbers, but I could not discover one myself. Finally, late in the night of July 25, I crossed a small stream on my way home from a frog hunt and saw a green snake lying in the bed of the stream. It proved to be one of the bamboo snakes, but I was not sure about its habitat until four nights later when I came across a second one in the bed of a stream.

This one thrashed the tail end of its body about in a most alarming fashion while being caught. Later night hunts confirmed my belief that I had found at least one favorite haunt of this pit-viper. Its choice of the stream beds as a lurking place is probably due to a fondness for frogs as food; the first of these two snakes had disgorged a freshly eaten frog.

Every would-be snake hunter wants to know: "How many snakes should a good collector catch in a day's hunt?" The only safe answer to this question is: "None or more." In snake hunting there is a strong element of pure chance. If a definite locality is named, one can give a better answer. For example, Mr. Klauber describes the situation in San Diego County, California, as follows:

"One may often fail to secure a single specimen on an ideal day at the peak of the season, and again a good catch may be obtained under what appear to be unfavorable circumstances. In this country six snakes may be considered a good day's catch for two persons hunting afoot during the best time in spring, this not including garter snakes hunted along a creek. This refers to persons with experience in snake hunting; the experienced collector can see and find snakes where the ordinary person would pass them by unnoticed."

It is not difficult to find accounts of enormous catches made from dens or places where species congregate for various reasons, but such accounts reflect conditions that few of us will be fortunate (or unfortunate?) enough to encounter. Most such accounts in this country tell of rattlesnake dens that harbored as many as a hundred snakes.

Colonel M. L. Crimmins, an authority on venoms and a veteran collector, writes that he averaged twenty-eight rattlers a season for three years in the El Paso region of Texas. He also tells how some Mexican cotton pickers spend June, July, and August catching snakes instead of picking cotton. These snakes are sold to local dealers by the pound—in 1926 the price was about thirty-five cents a pound—and during one season approximately five tons of snakes were bought in the region south of San Antonio.

No one knows how many cotton pickers it took to secure the five tons of snakes, but the seasonal average of twenty-eight caught by Colonel Crimmins gives us a good idea of collecting possibilities in Texas.

Little equipment is necessary for snake hunting. Bags of various sizes should be carried because they are the best possible containers for snakes. (See illustration facing page 133.) Under no circumstances should anything holding a snake be left in the sun. This rule must never be forgotten. Light gloves are used by some as protection against the inconsequential bites of harmless snakes. Such bites can be ignored or touched with iodine. In country where large poisonous kinds may be encountered high leather boots or thick puttees afford partial protection. In such places it is also prudent to use some implement in turning over objects or investigating dark crevices. The proverbial forked stick to be used in pinning snakes should be replaced by a short stick with an angle iron firmly screwed at one end. This is useful in pulling large snakes about as well as in pinning them down.

Although I know of no region where any great numbers of the population are constantly engaged in catching snakes, these animals are nevertheless hunted to some extent wherever they occur in abundance. Here are some of the reasons why they are caught: to supply the demands of the novelty and leather trades, or those of zoological parks, carnivals, circus side-shows, snake charmers, museums, schools, and institutions making anti-snake-bite serum. In the United States, China, and many other parts of the world snakes are used as medicine, and in Canton they are also considered a table delicacy. The canned meat of Florida rattlesnakes might even become popular in the United States if it were not so expensive. It has long been a custom of governments to offer bounties for the destruction of poisonous snakes, and religious cults in many parts of the world use them in various ways.

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SNAKES AS PETS

When I mention snakes as pets I am often asked: "But do they make intelligent pets?" in a tone of voice that tells me my inquirer is certain that they do *not* make intelligent pets. I always answer: "No," because of course my inquirer is thinking of *my* snake as compared to *his* dog. If I say: "Yes," sooner or later I may be forced to admit that my snake won't fetch a stick or stand on its hind legs at command.

Dogs are excellent pets because they are both intelligent and companionable, but when we analyze these two traits, we find that both of them are human ones. A dog, then, is a good pet because it has human qualities. In contrast to this, a snake is an attractive pet because it is in itself interesting and anything but human in form or behavior. A dog is a good companion, a snake an interesting object for observation and study. The two do not conflict or compete—each has its own distinct appeal.

Although there is no harm in having a foreign snake or one that has been brought from a great distance, I should recommend keeping local species, especially specimens that you have caught yourself. When you yourself find a snake, you learn where it lives, and knowing that helps you in making a good home for it. Moreover, it will be living in a suitable climate.

After you have secured a snake you must remember two rules: Never try to frighten anyone with it, and always treat it gently. When you scare your friends you keep them from liking snakes and the snake from becoming tame. It is always well to ask a person whether he or she wants to see a snake before bringing it into view.

Since I assume that you will not keep poisonous kinds, I shall not advise you to use snake sticks and the like. It is much better to put gloves on; loops, tweezers, and other grasping devices are likely to injure or frighten your pets. Avoid letting a snake hang, especially from a grasp on its neck; they prefer to be well supported and allowed to take a comfortable position by themselves. In raising one up, put at least one hand under it. Grace Olive Wiley had a large specimen that became very fond of a paper bag. Instead of lifting it out, she would thrust her hand into the bag and under the snake. Then, when she removed the bag, the snake was already comfortably arranged on her hand. This illustrates the kind of ingenuity that you too must use. (See illustrations facing pages 132 and 148.)

A wild, active specimen cannot of course be handled so readily. It should be approached gradually and not picked up at all if it persists in being wild. An individual that is still a little nervous and tries to bite can often be taken up after a light cloth has been dropped over it. Many snakes will not bite the hand that holds them or on which they rest but strike viciously at any approaching object. Snake catchers of Burma capture king cobras by attracting their attention with one hand while the other lifts them from the ground.

Snakes seldom fight for the sake of fighting, so different kinds can be mixed if no king snakes or other snake-eating species are involved. In general, it is safest to group your specimens by size because very small snakes occasionally fall victim to large individuals of species that do not habitually feed on snakes. Captive snakes sometimes even devour their own young.

Experiments have shown that snakes aggregate or gather into groups to reduce the amount of water lost through their skins and breath. The higher the temperature and drier the air the more beneficial aggregation is to them. The number of specimens that can be kept in one vivarium is largely a matter of convenience and appearance. Crowded cages do not look well, cannot be easily cleaned, and observations on the behavior of the individuals in them are difficult. You cannot always tell which snake has eaten, sloughed, thrown up a meal, defecated, and so on.

Making and arranging homes or vivaria for small animals is a study about which many books have been written. Obviously I cannot do more here than give you a few helpful pointers.

First, you should know that snakes do surprisingly well in a plain box containing nothing but a water vessel, an object to hide in or under, and, when shedding, something to crawl through. Many persons will say: "But how badly snakes kept like this must miss their natural surroundings!" It is, however, doubtful how much appreciation cold-blooded animals have for their "natural surroundings." They do have certain very definite requirements, among which are suitable temperature, humidity, food, and water; when these are fulfilled they ask no more.

This does not mean that you should not fix your vivaria up as much as you please, but just remember that your pets will prefer a plain cage with their fundamental requirements taken care of to an elaborately arranged one that is too damp or too something else. Also remember that a vivarium with large specimens in it is more easily kept clean if simply arranged.

The value of fixing a vivarium up depends somewhat on the size of its occupants. One housing a ten-inch snake can be made to resemble the true habitat of the species whereas your cages would scarcely be large enough to allow you to do the same for a six-foot specimen.

In selecting materials, you must bear in mind certain facts: Wood is easy to secure and handle but has the disadvantage of preventing sufficient circulation of air and of being opaque; glass is transparent but, like wood, stops the movement of air; wire netting has the one disadvantage of being so rough that wild or very active specimens generally injure their snouts by rubbing against it; metals are opaque, stop ventilation, and, very expensive ones excepted, quickly rust out.

These facts make it clear that wire is indispensable for ventilation, glass is valuable for vision and light, metal and wood are useful for framework, bottoms, and sides. Perforated metal could of course be used instead of wire screening.

If a snake rubs its nose against screening you should cover the latter with some soft thin material such as cheesecloth. Use cellophane if cloth obstructs your view and you expect the snake to get over its bad habit soon. Cellophane is cheap at ten-cent stores and therefore convenient but it stops ventilation. If the snake persists try cloth dark enough to cut out the attracting light. Sufficient ventilation is important because snakes get sick in damp moldy quarters.

If you use a wooden bottom, waterproof it with shellac, varnish, or paint so that it will not absorb water or moisture from excrement and stay damp. Secondary bottoms help a lot in keeping vivaria clean and dry. This is especially true if the secondary bottoms are somewhat raised and have a central hole cut just large enough to allow a water vessel to sink into it. Every vivarium should be made so that an entire side can be removed. This makes cleaning and airing a simple matter.

Before deciding on materials and a general plan visit the nearest reptile house.

The size of a vivarium is not especially important where snakes are concerned. It is largely a question of available space and convenience in handling. As a rule several small vivaria are better than a few large ones and, at first, cheap ones are preferable to expensive ones. As your experience grows and you think of good improvements, you can use more elaborate styles. A vivarium twelve inches long by eight deep and six high should make good quarters for three or four snakes a foot or less in length; double these dimensions and you will have the size of a home for as many snakes two to three feet long.

Finally, remember that all snakes are Houdinis when it comes to escaping. Your vivaria must be absolutely "snake-tight" and you must never take chances with doors even if you expect to be "right back." A specimen of about the rarest snake of New Jersey fooled me recently. It stayed in a fish bowl for a week and then got away. I had convinced myself that it could not get out because of its small size and the shape of the bowl. The fact that a snake does not make an escape for a week or two often proves nothing.

It is absolutely necessary to keep a snake's quarters clean and, in most cases, dry; even water snakes do not like damp floors. Secretive kinds that live in moist places can of course be given moist sand or earth to hide in. Excrement must be removed as soon as possible and uneaten food should not be allowed to create bad smells. A weekly change of water will suffice unless you are offering water at regular intervals to record the amount consumed.

In feeding snakes you must keep in mind the following facts: All snakes are carnivorous; their food is never chewed, and surprisingly large objects are easily swallowed; digestion is more rapid in a warm than in a cool place.

Many captive snakes have a most discouraging way of paying not the slightest attention to food and thus starving themselves to death. Your biggest problem in caring for snakes will be this question of getting and keeping them "on feed." My advice is to make this your chief consideration in choosing individuals for pets. A snake that refuses to eat will give little pleasure but cause much worry. If it is a local specimen, turn it loose when it has not eaten for eight or ten consecutive weeks of the warmer five or six months of the year.

A snake that eats well through the spring, summer, and fall can safely fast during three or four cold months even though kept in a warm place. Captive snakes of a temperate climate often feed indifferently during the winter. It is best to give them smaller and less frequent meals in the cold months because a heavy meal swallowed by a snake that is in a sluggish state can do great damage.

Although snakes can subsist on three or four large meals a year, good feeders will often consume a surprising amount of food, the excess being quickly stored as fat. In feeding these reptiles you have a choice of possibilities ranging from six to eight good meals a year to two or three small ones a week! I should advise giving a meal of moderate size once a week or a large meal every ten days. A large one may throw a specimen "off feed" so it is safer to give moderate ones. But what is a "moderate" or "large" meal? Let us put it this way: A large meal is one that, after reaching the stomach, stretches the skin so that the rows of scales stand apart. If a very long object is swallowed one cannot judge this way. In that case, or when several small ones have been eaten, you will simply have to judge the best you can.

It is often said that snakes will not touch dead animals. Experience in zoos has proved that prey is consumed about as readily dead as alive. Persistent effort will even teach many snakes to feed regularly on strips of raw meat.

Mr. Snedigar, of the American Museum of Natural History, teaches garter snakes to eat raw meat by first mixing chopped earthworms with ground meat and then gradually reducing the proportion of chopped earthworms. The snakes will eventually feed from a pile of meat.

You must remember that these reptiles depend a good deal on vision, and movement attracts their attention. When dead food is offered it should be shaken or moved just in front of the snake. In doing this it is well to use a pair of forceps that enable you to keep everything out of view except the food. A clever person can think of various tricks such as hanging the animal by a string attached to the top of the vivarium so that it will swing near the snake, peeling a bit of skin back to increase the odor, and so on. If the food is suspended thus, the string must be joined to foot or tail by a piece of cotton that will break at a slight pull. If this precaution is not taken the snake may swallow the string and remain suspended by it. Leaving the meal in overnight is often a good thing to do.

Some persons like to feed snakes in a special box, and this may be a wise procedure when you have several good eaters together. It is dangerous to allow two snakes to seize the same object because the smaller one is apt to follow the food down the throat of the larger. A specimen being offered food can of course be protected from others in the same box by a piece of cardboard.

Forced feeding is often resorted to by those anxious to save highly prized specimens. This practice is not to be recommended and should never be used until food has been refused repeatedly for several weeks. It is much better to keep only good eaters. Injury to the lining of the mouth often causes serious sickness. The safest way to feed by force is to introduce a mixture of raw egg and milk into the throat by means of a soft rubber tube. A relatively small frog or skinned mouse may be impaled on a stick and very gently pushed down a starving snake. The best method is the one that can be used with least violence.

As a matter of course, water should be kept in every vivarium unless you are offering it at regular intervals. About the only snakes that cannot be made to drink are those so wild that they will not allow themselves to be handled at all. Put a snake's mouth completely under water and watch the back of the head on either side; a regular expanding and contracting there accompanied by a slightly open mouth shows that water is being consumed. A starving snake lasts much longer if given plenty of water. Some specimens are stupid about finding a vessel, so it is just as well to see that your pets drink once in a while. Many snakes occasionally lie in their water containers but, as far as I am aware, no snake in the United States is so aquatic that it dies if deprived of water to swim or bathe in. Even the semi-aquatic water snakes live and grow well on no more than enough water to drink.

The center of a vivarium housing large snakes is the best place for their water. This is because snakes generally lie along the sides and a vessel kept in a corner or at one side is soon turned over or pushed about and spilled. Ten-cent store butter dishes make excellent water receptacles.

In regulating the temperature for your snakes you must bear in mind three facts: First, the temperature of a snake stays about the same as that of its surroundings; second, a snake is even more seriously damaged by excessive heat than by great cold; third, a snake lives better and digests more rapidly when warm than when cool, so a heavy meal on a cold stomach is bad for it.

Reptile houses are often kept at a temperature of 86° F., but it is certainly not necessary to keep snakes in such a warm atmosphere. They live quite well at 72° F. and occasional drops to 60° or a little below should not hurt them. Each species has its individual preference. For example, careful experiments have shown that DeKay's snake, in a relative humidity of 35 percent, does not like to be heated above 86° F. or cooled below 70° F. Continued cooling puts a snake in a semi-torpid condition and throws it off feed; heating above 100° F. is dangerous. Its body can stand about the same degree of "temperature" that yours can; when your "fever" passes the hundred mark you become sick. Benedict found that rattlesnakes died as a result of being heated to 104° F., and

Mosauer proved that even the sidewinder, an inhabitant of our hot southwestern deserts, rapidly succumbs when its temperature reaches 113° F. Although snakes are often attracted by the warmth of sunlight, there is no surer way to kill one than to subject it to too much strong sun. This is because a reptile's body absorbs heat like an iron bar. At least in the summer a vivarium should be placed so that its inmates are always free to get into shade. I vividly recall losing a beautiful pilot black snake by turning the front of its box toward an early afternoon sun; my pet was dead before I thought that it was even warm. A wooden box is especially dangerous because it keeps the heat in; a metal one is still worse.

When a wild snake suns itself it is of course free to crawl into shade as soon as comfortably warm. Sunning snakes are often near clear running water or up in foliage where they are cooled by breezes or partly shaded. I once saw a common water snake in New Jersey that, while lying on a piece of rusty metal, was exposed to a strong July sun. The cool water flowing over part of the metal undoubtedly kept it from getting too hot and the proximity of the snake to water also must have had considerable cooling effect.

Normal shedding is one of the best indications of good serpentine health and growth. You should therefore pay special attention to this process in making out your record sheets as indicated at the end of this chapter. You may learn more by comparing direct observations recorded in your notes than by studying the following brief account.

Snakes kept at a high temperature shed more frequently than those kept at a low one, so you can expect variation in frequency of shedding; good condition is indicated by a normal process rather than by uniform intervals.

Several days before a snake casts its skin, the eyes become cloudy, the skin loses its gloss or polish, the colors grow dull and the pattern obscure. Food is usually refused and a change for the worse in temper may be noticed. The high point is reached when the eyes become clear again; the snake soon rubs its head on any available object to loosen the edges of the skin along the lips. Once the head is free, the healthy snake generally succeeds in ridding itself of the entire skin as one piece by crawling through grass, rocks, or anything else. The whole process may require only a few tens of minutes. The skin is some ten percent longer than the snake and can be safely handled before it dries out or, after drying, if barely dampened. Even large pythons cast complete sloughs when kept in the pink of condition.

Slight difficulty in sloughing may be overcome by warm baths. In fact, water is often sought by snakes about to shed. Gentle assistance may be given but only when there is no doubt about the skin being ready to come off. Peel a snake too soon and you have killed it. Local specimens that obviously need to shed but are unable to do so even when helped by baths should be turned loose.

If one of your snakes lays eggs, by all means try to hatch them out so that you can watch the young use their egg-teeth in escaping from the shells.

In caring for the eggs you must remember five things: Handle them with great care and as seldom as possible; immediately remove them from the mother's vivarium; keep their hatching medium damp; the rate of development increases with a rise in temperature; newly hatched young are active and will escape if given half a chance.

Five convenient materials in which to hatch eggs are sand, sawdust, Spanish or sphagnum moss, wood pulp, and air. I have found sand very satisfactory because of its relative freedom from harmful molds and fungi.

A description of a simple method of bringing the eggs through follows. Fill a glass bowl or small aquarium with damp sand, bury the eggs one or two inches below the surface, cover the container securely with cellophane or a piece of glass and put it preferably but not necessarily in a sunny place. It is well to mark the exact position of the eggs with slender sticks so that you can remove the sand on either side and safely examine them every ten days. Thus you can be sure that they remain in good condition and that the sand about them stays damp. Sand dries out very slowly in a closed container. As hatching time approaches the shells lose their tautness and the eggs become bumpy and shrink somewhat. The covering layer of sand should then be thinned and protected from strong direct rays of the sun; a newly hatched snake is quickly killed by strong sunlight.

Essentially the same method may be followed if sawdust, decaying wood, or moss is used instead of sand. These materials are apt to contain injurious mold, and eggs kept in them must be watched closely. When air is used the eggs should be put in a tightly covered metal box having in it first a thick layer of damp sand, then one of thin rocks and, finally, a bare one of eggs. The latter, unless adherent in a bunch or bunches, should not touch one another. Their container can be placed in any warm place but not in direct sunlight.

The more you learn about your snakes the more you will enjoy them. The outline given below tells you some interesting things to observe and record. Writing down all of this information about a single snake would not be hard for one person; if it is a question of several persons being interested in a whole collection, any one of the eleven subjects could be recorded for all the specimens by the same boy or girl.

INDIVIDUAL RECORD SHEET

1. Names and Sex

Scientific, popular, individual. Illustration facing this page shows how to sex a snake.

2. Source

How and when secured; caught by whom.

3. Origin

Time and place of capture.

4. Growth

Monthly record of body and tail length, girth and weight (the latter taken at least five days after feeding).

5. Feeding

Date of each feeding and description (name, size, weight) of food taken; notes on readiness in accepting food and on refusals to eat.

6. Drinking

Offer a measured quantity of water at regular intervals and record amount consumed.

7. Elimination

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SNAKE-BITE AND ITS TREATMENT

Experiments have proved that seedling rootlets do not grow well in solutions containing snake venoms, so even plants cannot boast of immunity to these poisons. Here at least is slight support for the stories of tree-killing snakes although it is hard to see just how even the most efficient biter could inject its poison into a tree.

Animals, with their thin skins, soft flesh, and rapid circulation of body fluids, make perfect victims. Because of his large size, man is fairly resistant, and the glands of many small species such as the pygmy rattlesnakes simply do not hold enough venom to kill him. On the other hand, those of an adult Indian cobra usually contain sufficient poison to kill some fifteen humans and even the common krait of India may carry five death-dealing doses. Colonel Crimmins states that the adult western diamond-backed rattlesnake gives about nine lethal doses at a bite. This of course means a *good* bite!

The bite of the king cobra is often fatal in less than an hour. Fayrer found that 23 percent of the deaths from the bite of the Indian cobra occurred within two hours and that only 21 percent of those that died survived more than twenty-four hours. The snakes of the United States do not cause such rapid death because the pit-vipers overwhelmingly predominate here and have a relatively slow-working venom. Hutchison reports twenty-five fatal (chiefly rattlesnake) cases, only one of which succumbed in less than two hours, another in just that length of time, and fourteen in from eighteen to twenty-four hours. Only four lived more than a day.

These facts show that, although some venoms kill more quickly than others, all of them have the common characteristic of killing quickly or not at all. You must understand that the above remarks deal with fatal cases only and not with the total results of bites. The death rate in this country ranges from 3 or 4 percent, in cases receiving prompt and proper medical attention, to about 15 percent in poorly treated or untreated ones.

The real purpose of this chapter is to tell you about the treatment of snake poisoning, but before doing this I want to describe the chief effects the venom has once it is injected into the human body. Except in very unusual cases, this poison does no harm if put on the skin or swallowed.

Venoms contain two types of harmful substances. Those of one type are best described as cell-dissolvers because they destroy or paralyze nerve cells, seriously damage blood cells, and rupture the walls of capillaries and other small blood and lymph vessels. The nerve-affecting element, or neurotoxin, is the worst of these three, and the hemorrhagin or attacker of the blood vessels comes next.

Without being a doctor, one can easily imagine some of the serious results of destroying the capillaries, the indispensable links between arteries and veins. Damage to these microscopic blood vessels turns blood and lymph loose in our tissues, bringing about congestion and inflammation. Moreover, this, combined with destruction of red blood cells by the hemolysin, prevents the blood from supplying our bodies with the necessary oxygen. Neurotoxin attacks important nerve centers such as the one that controls breathing, so it is little wonder that the venoms containing large amounts of this element succeed in bringing on death most quickly.

The second type of harmful substance includes four or five elements, most of which affect animal tissues in essentially the same way that our digestive juices affect the meat that we eat—they begin to digest living flesh as soon as they are injected into it. The effects of these digestive elements are not considered very serious but the final member of this type, the so-called antifibrin ferment, keeps the blood from clotting and greatly aggravates the general internal bleeding caused by the hemorrhagin. Some venoms, such as that of Russell's viper, have exactly the opposite effect and bring about rapid death in small animals by making large clots in the blood vessels. However, this effect is not produced in man and other large animals, so we need not discuss it here.

Finally, venoms add insult to serious injury by greatly reducing the ability of the blood to combat infections invited and encouraged by the conditions resulting from the general cell destruction.

Fortunately for us, the poisons of the pit-vipers of the United States contain relatively small amounts of neurotoxin and are therefore not as quick to kill as are the chiefly nerve-affecting poisons of the cobras and their allies. Our coral snakes are members of the cobra family and carry very dangerous venom but, due to their small size and secretive habits, few people are bitten by them. The South American rattlesnake, with its strongly neurotoxic venom, forms a remarkable exception to the general run of pit-vipers.

Specialists believe that these more dangerous nerve-damaging elements were developed in venoms before the hemorrhagins and hemolysins. If this is true, snakes have really grown less rather than more dangerous. Our diamond-backed rattlesnakes would be truly terrible creatures if their venoms, which are secreted in such large quantities, were predominantly neurotoxic in action. For example, an average western diamond-backed rattlesnake could carry at one time enough venom of the strength of that found in the tiger snake of Australia to kill 400 or more men or about 135 horses.

Since the development of the use of antivenin or snake-bite serum in the Americas, there has been some contention over methods of treatment because of two conflicting theories about how the poisons of pit-vipers attack the human body. The backers of serums maintained that the poisons are so rapidly absorbed that cutting and bleeding at or near the site of the bite was all but useless; the believers in cutting and sucking held that venom is only slowly absorbed and can be drained from near the site of the bite for many hours.

Dr. Dudley Jackson, leading advocate of the cut-and-suck method, injected a dog with four M.L.D. of rattlesnake venom, employed his regular suction treatment, and injected some of the bloody fluid extracted into each of four other dogs, all of which showed severest symptoms of poisoning and either died or had to be killed, the original dog alone surviving. He also produced serious poisoning in a dog by injecting it with fluids drained from near the site of a bite in a man fourteen hours after occurrence of the bite. More than one hundred similar experiments were performed by Dr. Jackson and his associates and now, in this country at least, even the makers of antivenin advise local cutting and sucking.

It was formerly taught that venom was immediately carried to the heart and other vital parts of the body through the veins, but Jackson believes that it reaches the vital organs primarily through the lymphatics. Lymphatics are vessels that conduct the blood serum or lymph that escapes among the cells back to the general circulation at a point near the heart. The lymph makes only a half-circuit from the cells to the region of the heart, whereas the blood makes complete rounds of the body. Moreover, the lymph does not move as fast as the blood and tends to gather about a place where foreign substances have entered the flesh.

When venom is first injected it sets up a violent local irritation because it is not readily absorbed until greatly diluted. The blood and lymph that quickly gather slowly dilute it sufficiently to allow absorption by the lymph, which in turn carries it toward the heart. Only after it has reached the vital organs via this route do general, serious effects develop —prostration, convulsions, bloody discharges into the digestive tract, failure in breathing, and so on.

This explanation makes it clear that local treatment is of the utmost importance because every milligram of poison drained out near the site of the bite leaves that much less to be carried to where it can do more serious damage and also that much less to cause local destruction of blood cells and vessels and prepare the way for serious infections such as gangrene.

Jackson worked with the pit-vipers of the United States and it is to the absorption of their venoms that his explanation specifically applies.

We have now come to the actual treatment of snake poisoning. Wall makes a sharp distinction between snake-bite and snake poisoning to emphasize the importance of being sure that it is a poisonous snake that inflicted the wound before injecting serum and lancing. Serum may make a person who has no venom in his system very sick.

It is right here that knowledge of snakes becomes necessary. Everyone living, traveling, or working in country districts should unhesitatingly recognize all the local poisonous species. Persons bitten by harmless snakes that are considered poisonous may become sufficiently demoralized as to be unable to act or they may even die of shock.

In the case of small children, knowledge is especially important. For example, a six-year-old girl was bitten in Texas by a rattlesnake while she was trying to find something that "sounded like a locust." Even at the age of four, a child is quite able to recognize such a sound as a sign of danger as well as to learn the color patterns of many snakes.

If a zoo is visited the local poisonous and harmless species should be carefully compared one to another. If no suitable exhibit can be found, it should be asked for; zoos are quick enough to respond to such reasonable requests.

In trying to decide whether a harmless or poisonous snake made any particular wound, remember that each poison fang stands alone (or temporarily as one of a pair of teeth set closely side by side) whereas the corresponding teeth of harmless snakes are in long series and make uniform rows of punctures. Do not forget, however, that our poisonous snakes have a series of small teeth on either side of the palate that may also pierce the skin but these series are nearer together than are the fangs of the opposite sides of the jaw. It is not necessary to say that the careful but cautious examination of the severed head of the offending snake would often be the quickest way to decide the matter. In this connection it may be well to know that "dead" snakes, like "empty" guns, sometimes bite. Among 2342 cases studied by Dr. Githens, fourteen were due to this sort of misunderstanding.

The extremely rapid action of venom will help you come to a decision. The first symptom is a sharp burning pain that immediately follows the bite. Distinct swelling within ten minutes and profuse bleeding from the fang wounds are additional signs. Nausea and faintness often follow but these may be the result of fright.

The ability of the patient to keep up courage is of great importance. Remind him that there are several reasons why the snake may not have injected much venom and, even if it did, his chances of recovery with little or no treatment are about eight to one; with good treatment perhaps thirty to one. If the snake is a copperhead or a pygmy rattler of no matter what size, or a small specimen of any other species, the bite should not be dangerous to the life of an adult or to anyone whose size approaches that of an adult.

The following steps in first-aid treatment are now quite universally agreed upon:

1. Apply a ligature or tourniquet a short distance above the bite. Do not make it very tight as it is intended to completely stop the flow of lymph without greatly retarding the circulation of blood. Loosen it every fifteen minutes for about a minute. Elastic rubber tubing makes the best ligature but a necktie, shoestring, or handkerchief may be used and tightened by the twisting of a stick.

2. Make (preferably under novocaine) short cross cuts over the fang punctures with a sharp sterile instrument such as a one-sided razor blade or a knife. These cuts need not be more than a quarter of an inch deep or long unless one is made longer to connect the fang wounds, or the snake is a large diamond-backed rattler. (If a doctor can be reached within a few minutes, this cutting should of course be left to him.)

3. Apply suction to these cuts with the mouth or with a mechanical device such as is found in all cut-and-suck snake-bite kits. Keep this up for twenty or thirty minutes. The venom will not hurt the mouth or stomach if no sore or cuts are present. An empty antivenin syringe can be turned into an efficient suction pump by inserting the plunger backwards and re-attaching its handle through the end of the syringe barrel to which the needle is ordinarily fastened.

4. As soon as convincing symptoms are evident and cutting and sucking have been initiated, administer antivenin according to directions found with it.

5. As swelling develops, make shallow cross cuts over its worst part as well as near its base and suck out as much fluid as possible. These cuts need not be more than an eighth of an inch long or deep but should completely encircle a badly swollen limb. Check bleeding from larger blood vessels passing the site of the bite in order to conserve all unaffected

blood. The spurting of blood from an accidentally severed artery can be checked by a properly placed knot in the ligature or the insertion of a solid object over the artery and under the ligature.

6. Get the patient to competent medical help as quickly as possible without allowing him to run or become overheated. Strong coffee or a teaspoonful of aromatic spirits of ammonia in a glass of water should help keep up his courage.

Do not give alcoholic drinks. Potassium permanganate must neither be injected into the body nor rubbed into the cuts; a weak solution of it may be used as a wash for the cuts if no other antiseptic is available. Burning with gunpowder or a hot iron, or cauterizing with acid or anything else can only make matters much worse. All "folk-lore" remedies such as applying the insides of a freshly killed fowl or soaking the wound in kerosene merely invite tragedy by wasting valuable time.

If the only available doctor has no knowledge of proper treatment he may secure information by wire from the United States Public Health Service.

After first-aid treatment, which would probably occupy much of the first hour, cover the incisions with cloths soaked in a strong hot Epsom salt solution. An antiseptic such as bichloride of mercury 1 part to 10,000 in water will help to prevent infection. Remember that the natural resistance of the body to the invasion of bacteria is greatly lowered. Apply suction to the cross cuts for fifteen or twenty minutes of every hour and make new incisions as long as the swelling advances. Irrigation of the bowels with salt and soda solution is also advisable.

Preparedness for first-aid treatment of snake poisoning consists, then, of a little knowledge of dangerous snakes, the possession of one of the many cut-and-suck kits on the market and of one to three tubes of serum such as the Antivenin Nearctic Crotalidae prepared by Sharp and Dohme. This serum suffices for all of our species but the two coral snakes by which you are exceedingly unlikely to be bitten. The cut-and-suck outfits cost only about two dollars, but the serum is much more expensive.

Facilities for the local injection of novocaine are desirable additions since even the dread of pain will greatly undermine the courage of most of us. Dr. Jackson believes that novocaine may have some retarding effect on the spreading of the venom.

If you are forced to make a choice, by all means provide yourself with a cut-and-suck kit and let the serum go. The essential contents of one of these kits is a sharp instrument for cutting, a rubber ligature, and a rubber bulb sucking device with two attachments, one for a round surface such as that of the fingers, the other for a flat one.

It is worth remembering that good directions come in packages of serum and with many cut-and-suck kits. Make sure that what you buy includes up-to-date directions. Some companies sell outfits that contain serum as well as cut-and-suck equipment.

The production of the serum used in treating snake poisoning is clearly described by Dr. Githens, who is in charge of its manufacture in the Mulford Biological Laboratories, of Sharp and Dohme, Glenolden, Pennsylvania, the only place in this country where it is now being made. Dr. Githens's description follows:

"The dried venom made up in dilute solution is injected into horses, beginning with very small doses and gradually increasing the quantity as resistance to its action develops. After a few weeks there is found in the horse's blood serum a substance which has the power to neutralize or overcome the poisonous effects of the venom. The neutralizing effect of antivenin slowly increases in potency and after 3 or 4 months the horses are usually ready. The blood is tested by mixing 1 cc. of serum with different amounts of standard venom solution and injecting these mixtures intravenously into pigeons. When 1 cc. of serum is able to save the life of a pigeon given 1 mgm. of standard venom, the horse is bled. The blood is allowed to clot and the clear serum drawn off. The antivenin thus obtained is concentrated by a special process, after which 1 cc. will neutralize 3 mgm. of the dry venom. It is then put up in 10-cc. syringes."

You will recall that there are about 4 cc. in a teaspoonful and that it takes 1000 mgm. to make one gram and 28.3 grams to make an avoirdupois ounce.

No one knows how many human beings die every year of snake poisoning. Estimates run from only twelve persons in Australia to 20,000 people in India. It is probable that the Indian estimate is a gross exaggeration because no comparable figures have been reported from other parts of the East where the same types of poisonous snakes frequent thickly settled regions.

For example, Dr. Kopstein could get reports of only a few deaths per year on Java where about 40,000,000 people live and king as well as smaller cobras, kraits, and pit-vipers abound. Moreover, the population of Java is nearly four times as dense as that of India. To compare with India, Java should have 10,000 deaths every year! This figure more likely represents the number of lives accounted for by snakes throughout the entire world. In the United States alone automobiles kill more than 30,000 people annually, snakes probably about 160; for every person killed by a snake, 200 die in automobile accidents.

Strange as it may seem, scientific knowledge of snake-bite in the United States was not acquired until 1926. In June of that year a station of the Antivenin Institute of America was organized at San Antonio, Texas, and put in charge of Colonel M. L. Crimmins and Major R. E. Scott.

During the first year's work at San Antonio, data on 150 cases of bites by poisonous snakes in Texas were brought together but about half of these occurred within a radius of fifty miles of San Antonio. This fact clearly shows the great difficulty of getting information on cases of snake poisoning. In 1928 and 1929, the years of greatest activity of the Antivenin Institute, information on five to six hundred cases per year was secured, but since then the annual totals are steadily dropping. This is certainly not because fewer people are bitten but because data are not forthcoming. Estimates based on the work of the Antivenin Institute put the total number of bites in this country as between 1500 and 2000 per year.

Which of our snakes inflict these bites? The five villains responsible for 95 percent of all deaths are listed in probable order of their destructiveness:

Western diamond-backed rattlesnake
Prairie and Pacific rattlesnakes
Eastern diamond-backed rattlesnake
Timber rattlesnake
Water moccasin

The western diamond-backed rattler is the chief murderer of the gang and probably causes twice as many deaths as either the prairie plus the Pacific rattlesnake (subspecies of a single species) or the eastern diamond-backed rattler.

Some would add the copperhead to this list, but less than one percent of its bites bring fatal results, so I have given it the benefit of the doubt. Not a single death resulted from 308 copperhead bites recorded by the Antivenin Institute during 1928 and 1929. This snake, however, comes in for highest recognition when we list in order of greatest number of bites the seven species responsible for 98 percent of all cases of snake poisoning:

Copperhead
Western diamond-backed rattlesnake
Prairie and Pacific rattlesnakes
Timber rattlesnake
Water moccasin
Ground rattlesnake
Eastern diamond-backed rattlesnake

The copperhead carries away the honors here quite as conclusively as the western diamond-backed rattler does in the first list. Among these seven only the ground rattler can entirely escape indictment for murder.

If we could eliminate from our fauna the first two and the fourth species of the first list, our snake-bite mortality problem would be largely solved. The ranges and habitats of the eastern diamond-backed rattler and the water moccasin are so restricted that relatively few people come in contact with them, the high toll of death taken by the former being due to the large dose injected by it and its great size. If, further, the copperhead is put out of the picture, citizens of the northern half of the

United States would have only the massasauga to worry them, and its range is not extensive.

Figures for 1928 and 1929 show that only two percent of bites are inflicted between the elbows and the knees. Among a total of 945 bites, 529 were below the knee and 396 below the elbow. This shows you what parts of your body need protection. The legs can be protected in a variety of ways, but protection for the arms and hands is not so readily afforded. One simply must be careful about extending the hands in advance of the sight; "look before you reach" should be your slogan in pit-viper infested localities. It all comes back to the axiom that a little knowledge of snakes and their ways is your best weapon. It is a shame to waste your fear in places almost or entirely devoid of dangerous snakes but it is shameful to be bitten through carelessness or ignorance.

Dr. Githens found that one bite in every fifteen among more than two thousand studied by him was inflicted on persons intentionally handling poisonous snakes. This is good evidence of the danger that lies in such handling.

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CLASSIFICATION

About 2400 different kinds of snakes are known to roam the face of the earth. It has taken mankind nearly two hundred years to find this out, and he has not finished yet; every year new species are discovered. The last complete descriptive account of snakes was written by Dr. G. A. Boulenger and published by the British Museum in three thick volumes, the final volume appearing in 1896. This work described 1639 species, 1327 of which were represented in the study collection of the Natural History branch of the British Museum. This collection remains today the largest one in existence.

An average of twenty acceptable species per year has been described since 1896 or nearly two a month. This is not such a big number when we recall that there are perhaps two hundred well-trained herpetologists scattered throughout the snake-inhabited regions of the world.

A cook who had to work in a kitchen with pots lacking handles would never get a meal ready. Put handles on his pots and see the difference. It is this way with these 2400 snakes; they cannot be studied until each is given its handle, a scientific name. This name, once properly assigned, cannot be changed or attached to another animal; it becomes immediately a permanent handle.

In contrast to a technical name, a popular one is usually applied first to this, then to that snake, or even to a bird or mammal as well. The word "gopher" is a good example; it means snake to some, turtle or mammal to others. Order a "gopher" from several different animal dealers and see what a varied assortment of creatures you get! In all parts of the world snakes with blunt head-like tails are called "two-headed snakes." Everyone at all familiar with reptiles can readily add examples. The value of scientific names needs no further explanation—if they are an evil they are at least a necessary one.

But names do more than provide handles, they express relationships. Species much alike except for minor external differences are grouped into a genus; genera (plural of genus) that in turn resemble one another, form a family; related families are put into the same suborder; suborders are arranged into orders; several orders are called a class; and classes constitute phyla. Beginning with classes and working the other way we have, for example:

Class: Reptilia—all reptiles
Order: Squamata—snakes and lizards
Suborder: Serpentes (or Ophidia)—snakes
Family: Crotalidae—pit-vipers
Genus: *Crotalus*—rattlesnakes (except the pygmy rattlers)
Species: *Crotalus horridus*—the timber rattlesnake

Classification or taxonomy is based chiefly on anatomy. In arranging species into genera one looks for external points such as scale or color patterns, but in dealing with genera and families, internal characters generally must be used. With snakes most of these internal characters are found in the teeth and bones of the skull. Lacking real limbs, a snake has rather limited possibilities for variation in form. In this connection it is interesting that members of some of the primitive families such as the boas and pythons possess remnants of pelvic or leg bones or both and the latter may even be visible as tiny spurs, one on either side of the anus. Shoulder or forelimb bones are never present.

Herpetologists have compared the 2400 kinds of snakes and shown that they may be arranged in twelve families. Although the purpose of this book is to tell you how snakes live, it is only fair to give you at least a bird's-eye view of them as a whole. This is best done by writing a brief account of the families, beginning with the primitive groups, or those that probably appeared first, and working up to the most recently evolved ones, the vipers.

This account will also bring out the fact that the vast majority of snakes are harmless. Moreover, many species belonging to poisonous groups either cannot inflict a fatal bite on man or rarely ever do so because of a docile nature or a habitat that keeps them from coming in contact with this most destructive of mammals. I estimate that only 8 percent of the species of snakes deserve to be greatly feared by man.

FAMILY TYPHLOPIDAE

The worm-snakes are small harmless burrowing creatures with the eyes covered by scales. The great majority of the species belong to the genus *Typhlops,* a term that is derived from the Greek words meaning "blind" and "eye." Although chiefly of Old World distribution, these diminutive snakes are found in all tropical lands, the ranges of only a few extending into temperate regions. Their nearest natural approach to the United States is in the West Indies. A species found in the Bahamas undoubtedly reached those islands fortuitously. All the worm-snakes lay eggs and live on earthworms and soft insect forms.

About 6 percent of the known species of snakes belong to this group.

FAMILY LEPTOTYPHLOPIDAE

So striking is the general resemblance of the snakes of this family to those of the Typhlopidae that the members of both families are commonly called "worm-snakes." "Blind snakes" is another name that may be used for either group. There is, however, a fundamental difference in the dentition, this family having teeth only in the lower jaw whereas in the Typhlopidae teeth are confined to the upper. The Leptotyphlopidae are entirely harmless and found in southwestern Asia, over most of Africa and South America. From the latter continent they range northward into the southwestern United States where three species occur.

Between 2 and 3 percent of the known species of snakes belong to this family, which also frequently goes under the less acceptable scientific name Glauconiidae.

FAMILY UROPELTIDAE

The shield-tailed snakes are harmless burrowing reptiles only one or two feet long and immediately recognized by a small pointed head and peculiar tail. The latter ends in an enlarged scale or shield which is variously decorated by spines or tubercles. These remarkable snakes are confined to southern India and Ceylon, where they occur chiefly in mountainous regions. As far as is known all the species bear living young and subsist on earthworms.

About 2 percent of the known species of snakes belong to this family.

FAMILY XENOPELTIDAE

This family, with its single species, is included only for the sake of completeness. This one kind is aggressive and fond of eating other snakes. It inhabits Asia and the East Indian region.

FAMILY BOIDAE

The large species of this family, the giants of the serpent world, need no introduction since of all snakes they are the most familiar. Most of the members of the family are, however, of moderate or even small size.

There is no easy way to tell a python from a boa, their separation being based on tooth and skull characters. The distributions of the two groups help in some cases. Excepting one rare Mexican species, the pythons inhabit the Old World. There they are widely distributed though represented by not more than twenty species. The boas, with twice as many species, have headquarters in the New World and scattered representatives in southern Europe, southern and central Asia, northern Africa, Madagascar, and islands north and east of Australia. Two species are found in the western United States.

The boas and pythons are typically tropical snakes and all are harmless as far as ability to poison is concerned. Even the largest individuals seldom molest man. By virtue of size alone these giants are potentially dangerous and large examples should not be closely approached by the inexperienced. The boas bear living young whereas the pythons lay eggs. This is at least a general rule.

Two to 3 percent of the known species of snakes belong to this family.

FAMILY ANILIDAE

This small family includes a single South American species and a few others found in southern Asia and the East Indies. Although reaching lengths of only thirty inches or less, these reptiles as a group are aggressive and fond of eating other snakes. All are harmless and bear their young alive. The famous red snake that threatens with its brightly adorned tail is a member of this group. Its actions are described in the chapter on defense.

Less than one percent of the known species of snakes belong to this family, which is generally known by the less acceptable scientific name Ilysiidae. There is no widely used popular name in English.

FAMILY COLUBRIDAE

This enormous family comprises approximately two-thirds of all, or nearly 1600, species. No description is necessary, the members of the group being simply snakes as most people know them. For example, all the snakes of the United States except the rattlesnakes, water moccasin, copperhead, coral snakes, boas, and worm-snakes (or blind snakes) belong to the group.

In spite of great variation in size, form, and habits the Colubridae are subdivided with difficulty. In fact, some 1200 of them, or half of all the species known, are indivisible and stand together as the subfamily Colubrinae. The remaining ones, nearly 400 in number, differ enough to be separated into one large and a few small lots, but it is doubtful whether the large one, the Boiginae, forms a natural assemblage.

Its species are characterized by the possession of rigid grooved poison-conducting teeth in the rear of the upper jaw and include nearly all of the so-called rear-fanged snakes. Only a few of the largest rear-fanged species are dangerous to man and some are decidedly beneficial. A single kind, the famous boomslang of Africa, can be rated as highly venomous. It has been known to inflict fatal bites.

With the exception of a large part of Australia, the Colubridae are generally distributed over the warm parts of all the great land masses.

They are also abundant in the East and West Indies, especially the former.

Any member of this family may be called a "colubrid"—there is no popular name. The three succeeding families are frequently included among the Colubridae, swelling its already overcrowded ranks to comprise 75 percent of the world's snake species.

FAMILY ELAPIDAE

This is not only the second largest family of serpents but includes roughly half of all the truly venomous species. Its members, the cobras, coral snakes, kraits, etc., are at once recognized by the rigid erect poison-conducting teeth in the front of the upper jaw. Some of the larger kinds are among the most dangerous of snakes whereas many of the smaller ones are secretive burrowers or rare species seldom encountered by man.

Australia, with approximately sixty kinds, is the headquarters of the family today, and on that continent the species are varied in form and habits, one, the death adder, even being strikingly viper-like in appearance.

In the Americas, the family is represented by at least fifty relatively similar species of coral snakes, two of which reach the southern United States. Many of the coral snakes are gorgeous creatures brilliantly banded with red, black, and yellow. They are burrowers and subsist chiefly on other snakes and lizards.

On the continent of Africa, the Elapidae are surprisingly conspicuous in spite of the fact that great numbers of kinds do not occur there. This conspicuousness is due to the aggressiveness of certain ones: the renowned mamba, the "spitting" cobra or ringhals, and the true cobras, some of which also habitually eject their venom to a distance of several feet. The other African members have reached no such pinnacle of fame.

The king cobra or hamadryad reigns supreme as the ferocious giant of southern Asia and the East Indian region. The smaller but equally well-known Indian cobra spreads the fanciest "hood" raised by any snake, and two or three other cobras are found in the East Indies and Philippine Islands. In addition to these and several kinds of kraits, the family is represented in southern Asia and the East Indian region by a few small species recalling in form and habits the American coral snakes.

Almost 10 percent of the known species of snakes belong to this family.

FAMILY HYDROPHIIDAE

These, the sea snakes, are merely members of the preceding family which have taken to a marine life. They have the same rigid poison-conducting teeth in the front of the upper jaw but, in contrast to their land relatives, possess tails flattened from side to side to assist in swimming. Although their venom is dangerous to man, fishermen do not dread them because they are slow to bite. They are too small to have given rise to the sea serpent myths; the majority of kinds do not exceed four feet in length and the largest are only nine feet long.

In spite of perfect adaptation to an aquatic existence, the sea snakes frequent inshore waters rather than the open ocean. They are most numerous from the coasts of southern Asia to the shores of northern Australia. No species has reached the Atlantic (unless transported there by man) and only one has succeeded in crossing the Indian Ocean to appear on the eastern shores of Africa. This same kind, the yellow-bellied sea snake, is also found on the western coasts of America and has the most extensive range of any known snake.

The sea snakes live on elongate fishes such as eels. It was long believed that all of them brought forth living young but it is now known that certain ones come to the shore to lay eggs. The few that do this are, of all known kinds, the best adapted to progress on land. The majority of species are quite helpless out of their native element.

Between 2 and 3 percent of the known species of snakes belong to this family.

FAMILY AMBLYCEPHALIDAE

The few species of this family occur in southeastern Asia and the East Indian region. Several snakes of the American tropics have long been included here but recent investigation tends to place them among the Colubridae. The Amblycephalidae subsist on snails and slugs. Their long delicate teeth and an inability to swallow large objects seem to be correlated with this diet. No attempt is made to swallow shells, the snails apparently being eaten right out of house and home. As far as known, all of the Amblycephalidae lay eggs.

Scarcely one percent of the known species of snakes belong to this family.

FAMILY VIPERIDAE

The members of this and the following family have developed the most efficient poison apparatus of any reptiles, living or fossil. The fangs are beautifully made injecting needles capable of being folded back against the roof of the mouth when not in use. The Viperidae are known as typical or true vipers in contrast to the Crotalidae or pit-vipers. The typical vipers lack the facial pit or special sense organ found in all the Crotalidae. This pit is described in the chapter on senses and intelligence. Some true vipers do have a facial pit but it is not comparable in complexity to that of the pit-vipers.

The true vipers are unknown in the Americas but occur over central and southern Asia, most of Europe, and all of Africa. The largest ones and greatest number of species are found in Africa. Only one sort reaches the East Indies and there its distribution is very restricted. The Gaboon viper and puffadder of Africa, Russell's viper of southern Asia and the East Indies, and several European species are the best known members of the group. A great majority of the species bear living young.

Three percent of all the known species of snakes belong to this family.

FAMILY CROTALIDAE

As already explained under the Viperidae, the snakes of this family possess a complex facial pit and are known as pit-vipers. They are most abundant in the Americas, southeastern Asia, and the East Indian region, but unknown in Australia and Africa. One species crosses central Asia to reach extreme eastern Europe but otherwise the family is unrepresented there. The rattlesnakes, the water moccasin, the copperhead, and the tropical fer-de-lance and bushmaster are the best known among the New World pit-vipers. The vast majority of species bear living young. In the New World the bushmaster alone is known to lay eggs.

Slightly more than 4 percent of the known species of snakes belong to this family. Many herpetologists unite the Crotalidae and the Viperidae into a single family which is known as the Viperidae.

APPENDIX

HOW TO IDENTIFY THE SNAKES OF THE UNITED STATES

REMEMBER

Dorsal means pertaining to the back.
Ventral means pertaining to the belly.
Anterior means pertaining to the forward part.
Posterior means pertaining to the rear.
Lateral means pertaining to the side.
Median means pertaining to the middle.

INTRODUCTION

The sole purpose of the following pages is to enable you to identify and learn the distribution or range of any snake found within the borders of our forty-eight states. Identifications and ranges are logically treated together because every kind of snake has a definite range and your success in using the "keys" will depend largely on how well you keep this in mind. If the key says "southern Arizona" and your snake is from New England, pass quickly on until you come to a species that occurs in New England. You might even draw a line through all parts of the keys that relate to snakes from sections of the country in which you are not interested and thus save yourself a lot of time and trouble. If the origin of your specimen is unknown, you will of course have to "run" it through the keys character by character. Except in a few places, the keys are made to meet just such an emergency.

Do not expect the keys to identify specimens found south of the United States. They should, however, be good for snakes taken in Canada, since the few species of that country also occur in the United States.

The ranges of genera, species, and subspecies are stated as concisely as possible and in most cases the meaning is obvious. However, the method used in giving a roughly square distribution requires illustration: A snake occupying all the area of which Pennsylvania, Iowa, Louisiana, and Georgia form the corners, is said to range "From Pennsylvania westward to Iowa; southward to Georgia and Louisiana" or "From Pennsylvania southward to Georgia; westward to Iowa and Louisiana."

A few limited ranges are given for convenience in the keys to species.

When you look at these keys I know that you will immediately want to ask: "Why do you base them on technical scale characters instead of on color patterns?" My answer is twofold: First, I have used color in many places; second, color characters are too difficult except where only ten to twenty species are involved. Colors seem easy because you already know them, whereas you probably do not know how to count scales. As a matter of fact, it is vastly easier to determine whether an anal plate is single or divided than it is to choose between long descriptions of complex color patterns. Suppose you had to get over several hundred miles of uninteresting road and did not know how to drive an automobile; would you take a little time off, learn to drive, and ride in ease and comfort, or would you "foot it" simply because you already know how to walk? So it is with the key; once you learn a little about the scale arrangement of a snake's head and body you should easily "run down" the vast majority of specimens that fall into your hands. There will be exceptions because snakes are variable animals and some individuals do not conform.

The keys are necessarily compilations, since no one person has worked out the identifications of more than a few of our snakes. The only single work that I have used to any extent is Blanchard's *A Key to the Snakes of the United States, Canada and Lower California.* This herpetological classic is now hard to secure and somewhat out of date.

HOW TO USE THE KEYS AND LIST

In order to use the keys and list that follow you must first place a snake in one of the four Groups, then assign it to a genus within the proper Group. After this, note the number and name of the genus and turn to that same number and name in the List of Genera and Species.

If there is only one species in the genus, your identification will be finished; if there are two or three you will have to make a choice as indicated, but if there are several it will be necessary to "run" your species in a second key.

Finally, you will see at a glance that the keys are based on choices, for the most part between alternatives. For instance, the long key of Group III asks under A1 whether the specimen in hand has a keel on some of its dorsal scales. If you do not find keels, look for a large A2 with the same indentation as A1. Under this A2 there is a B1 that calls for an entire anal. Suppose your snake has such an anal, go to C1 immediately below. Should your specimen fit the conditions of this C1 it is a leaf-nosed snake of some species. Turn to Genus 16 in the List of Genera and Species and read that only two species of this genus occur in the United States. By bearing in mind the origin of your snake and counting the blotches on its back, you should have no trouble in choosing between the two possibilities.

Notice that right after the word *"Phyllorhynchus"* it says: "The scales may be smooth or keeled." This means that Genus 16 is found in two places in the key to Group III as, in fact, are several other genera. The necessity of doing this gave *me* considerable trouble but it need not disturb *you* once you know that repetition of a genus or species in a key is not an error, but merely indicates unusual variability in that genus or species.

If the species to which your specimen belongs is further divided into subspecies, you can determine the proper subspecies by the locality from which your specimen comes.

Most laymen are satisfied to carry a specimen only to its species, so I have not given keys to subspecies. Moreover, one must go into average scale counts and other technical points scientifically to determine subspecies. In two cases I have not even listed the subspecies.

Most subspecies of one species are much like one another in general appearance but, in a few cases, they are readily distinguished by widely differing color patterns. The best examples of these strikingly different subspecies are found among the species of Genera 19, 21, and 29.

You doubtless wonder why such distinct kinds are called "subspecies" instead of full species, and the answer is that "intergradation" occurs. In other words, if one subspecies ranges from the Carolinas westward to Texas, its fellow from Texas to the Pacific coast, there will be an area in Texas where individuals are as much like the eastern subspecies as they are like the western one. These individuals are the intergrades, and their existence keeps us from drawing a sharp line between the eastern and western subspecies. Subspecies, then, are strictly geographical units, and two subspecies of the same species do not occur in the same place except in the form of intergrades. Areas of intergradation are ordinarily very small as compared to the ranges of the subspecies concerned.

THE OUTSIDE OF A SNAKE

THE HEAD

The scales or plates of a snake's head are of great importance where identification is concerned. Note that all of them except Nos. 1, 4, and 18 are paired. These are the only three scales that are cut in two when a snake's head is divided in half lengthwise.

Looking at the head from above, the basic arrangement is simple: the central shield-shaped scale (No. 4), lying between the eyes, is surrounded by (a) one scale (No. 5) on either side; (b) a pair of large scales (No. 6) behind; (c) two pairs of smaller scales (Nos. 2 and 3) and a single scale (No. 1) in front, this last scale tipping the snout. Any departure from this arrangement is of great significance. Scales Nos. 1, 2, and 3 must be noted with special care because they are the variable members of the lot.

Viewed from one side, the paired condition of the lateral scales of course cannot be seen. The arrangement here is less symmetrical though scarcely more complicated. The mouth lies between two rows of scales (Nos. 16 and 17). The upper row (No. 16) is connected with the scales of the top of the head by a series of small ones (Nos. 7 through 15), which are of major importance in identifications and often difficult to make out. Most of the difficulty will be dispelled if you remember that the temple is a short distance behind the eye and that the word "lore" indicates the region between eye and snout. You can see that scales Nos. 14 and 15 lie in the temporal region, Nos. 10 through 13 border the eye in front and behind, No. 9 lies in the loreal (from lore) region, and Nos. 7 and 8 border the nostril.

These lateral scales are more variable in size and shape than those of the top of the head. Moreover, with the exception of Nos. 7 and 8, they are frequently more or less numerous than shown in the illustration, or even absent. In working them out, always use the eye and nostril as landmarks because it is in relation to these that the scales are arranged and named.

There is little to remember about the ventral or under view of a snake's head except that the two pairs of lengthwise scales (Nos. 19 and 20) are flanked by the series bordering the mouth (No. 17). Scale No. 18 tips the chin and is not paired. The keys do not require you to look at this part of a snake very often.

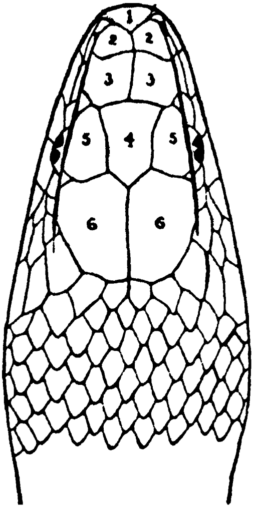


FIG. 1

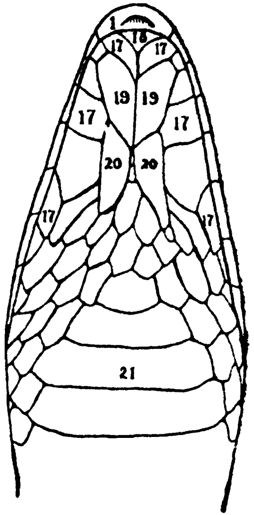


FIG. 3

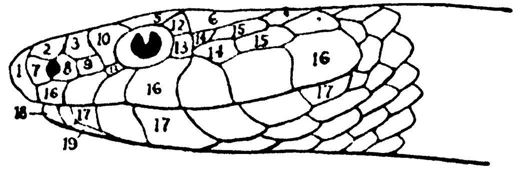


FIG. 2

Top, side, and ventral views of a blacksnake's head with the scales or plates numbered.

1. Rostral (covers the rostrum or snout)
2. Internasals (between the nasals, Nos. 7 and 8)
3. Prefrontals (before the frontal, No. 4)
4. Frontal (on the front or forehead)
5. Supraoculars (above the oculus, which means eye in Latin)
6. Parietals (on top of head to the rear)
7. Prenasals (before the nostril)
8. Postnasals (behind the nostril)
9. Loreals (in the region of the lore which is the side of the head between eye and snout)
10. Upper preoculars (upper scale before the eye)
11. Lower preoculars (lower scale before the eye)
12. Upper postoculars (upper scale behind the eye)
13. Lower postoculars (lower scale behind the eye)
14. Anterior temporals (first tier of scales in the region of the temple)
15. Posterior temporals (second tier of scales in the region of the temple)
16. Upper labials (row of scales of upper labium or lip)
17. Lower labials (row of scales of lower labium or lip)
18. Mental (covers the mentum, which means chin in Latin)
19. Anterior chin-shields
20. Posterior chin-shields
21. Ventrals

THE OUTSIDE OF A SNAKE

THE BODY AND TAIL

The skin of a snake's body and tail is in folds. These folds make the so-called "scales," which are not true scales at all. These folds or scales, as we shall call them, of the back and sides are protective, but those of the belly, when enlarged, are of great assistance in climbing as well as in one type of crawling.

The illustrations show how the skin looks when a section of it has been cut along the middle of the belly, removed and flattened out. The body scales lie in regular rows between the halves of the belly plates. These rows of scales are continuous along the back and sides from head to tail, but in most species a few of them drop out by pairs somewhere along the posterior half of the body. Therefore, in determining the number of scale rows, it is best to make three counts: one halfway between head and tail, one two head-lengths behind the head, and one the same distance before the tail. The highest of three counts is the number to use in the key. This triple count entails more work but it serves as an excellent check and gives you the most accurate results.

The four methods that may be followed in counting scales are clearly indicated by the illustration in which the scale rows are numbered 1 to 15.

Scales are either smooth or keeled. A keel is readily seen as a lengthwise ridge along the middle of the scale. The keels are most readily found on scales of the middle of the back at a point a little nearer to the tail than to the head. The presence of keels on scales of even a few rows indicates a keeled-scaled species.

The ventrals extend from the neck to the anal plate as a continuous series of undivided plates lying across the belly. The counting of these plates is often called for in technical keys.

The anal plate lies immediately in front of the anus and may be undivided (entire) like the ventrals or it may be divided (double). This is a very important character.

The subcaudals or plates under the tail are divided (double) in most American snakes and, therefore, obviously different from the ventrals. Subcaudal counts are of great importance in technical herpetology.

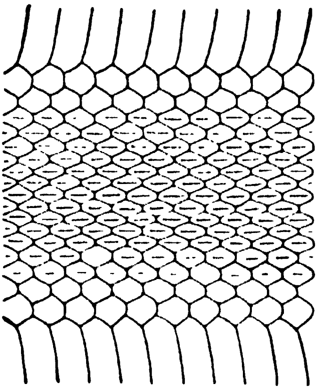


FIG. 5

A section of the skin of a keeled-scaled snake. Notice that the outer (or lowermost) rows are smooth. Very few species have keels on every row.

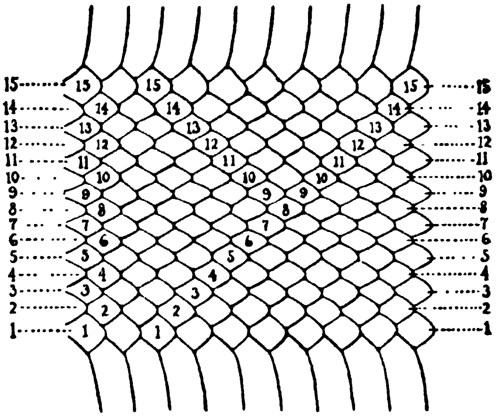


FIG. 4

A flattened-out section of skin with fifteen lengthwise rows of scales, illustrating how the rows are counted *across* the section or *around* the body of the snake. The scales shown here are smooth. Nine ventral plates have been cut in half.

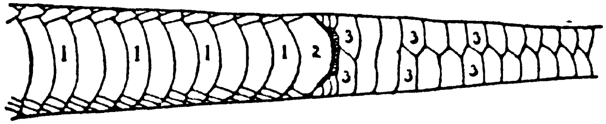


FIG. 6

The belly of a snake in the region of the vent or anus showing this orifice covered by an entire (undivided) anal plate (2). The subcaudals (3) are divided with two exceptions. This is an abnormal condition which may appear in almost any species. The ventral plates or ventrals are numbered 1.

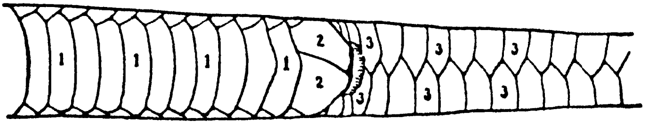


FIG. 7

The anal region of a snake with a divided anal (2) and divided subcaudals. Undivided (entire) subcaudals look just like normal ventrals. The anal may be entire or divided quite independently of the subcaudals.

KEY TO GROUPS AND GENERA OF SNAKES OF UNITED STATES

GROUP I. WORM-SNAKES. FAMILY LEPTOTYPHLOPIDAE. HARMLESS.

All snakes with scales on the belly like those on the back and sides belong here. Only specimens less than 14 inches long can possibly fall into this group of tiny worm-like reptiles. There is never a sign of a pit between the eye and the nostril or of a rattle on the end of the abruptly tapering tail. The upper jaw is entirely devoid of teeth. The few species are found only from Texas and Oklahoma westward to the coast.

1. Blind snakes (*Leptotyphlops*)

GROUP II. SMALL BOAS. FAMILY BOIDAE. HARMLESS.

Any snake with scales in more than 35 longitudinal series at midbody must be a member of this group. A series of transversely elongated scales, the ventral plates, is present on the belly and continues undivided beyond the anus along the lower side of the tail (Fig. 9). With very few exceptions the snakes of Group III have a single series of plates under the body, a double series under the tail. The small boas have moderately or very blunt tails always devoid of a rattle. There is no pit between the eye and the nostril nor sign of poison-conducting fangs in the jaws.

A1: A large central scale on top of head between the eyes (Fig. 8). Found from Utah, Wyoming and Montana westward and southwestward.

2. Rubber snake (*Charina*)

A2: Numerous small scales on top of head between the eyes. Found only in southwestern Arizona and southern California.

3. California boa (*Lichanura*)

GROUP III. COLUBRID SNAKES. FAMILY COLUBRIDAE. HARMLESS TO MILDLY POISONOUS

and

CORAL SNAKES. FAMILY ELAPIDAE. POISONOUS.

Leaving out of consideration the rattlers, about 95 percent of the species in this country fall into this group, so the chances of any specimen without a rattle belonging here are exceedingly great. A combination of three points immediately identifies one of these snakes: a series of transversely elongated scales (ventral plates) along the belly (eliminates it from Group I); 35 or fewer longitudinal rows of scales at midbody (eliminates it from Group

II); lack of a deep cavity or pit between eye and nostril (eliminates it from Group IV). In addition, it is well to see that there are no long movable fangs in the front of the upper jaw and that the plates under the tail are in a double series. A very few snakes with some undivided plates under the tail do, however, belong to Group III.

The two species of coral snakes (*Micrurus* and *Micruroides*) have short rigid fangs in the front of the upper jaw and possess a very dangerous poison. Because of secretive habits and shy dispositions they are not to be feared like the larger more aggressive pit-vipers of Group IV, but coral snakes should be avoided just as consistently as any other dangerous snakes.

Five genera of Group III, the rear-fanged snakes, possess grooved poison-conducting teeth in the rear of the upper jaw. Although the bites of these snakes are never dangerous and seldom even painful to man, specimens more than a foot long should be handled with care. The rear-fanged genera are: lyre snakes (*Trimorphodon*), black-banded snake (*Coniophanes*), annulated snake (*Leptodeira*), Arizona long-headed snake (*Oxybelis*), and black-headed snakes (*Tantilla*).

A1: At least some of scales on back with a median keel (Fig. 5).
  B1: Anal divided (Fig. 7).
    C1: Rostral turned up and keeled above (Fig. 10). Not found in Pacific states or Nevada. 4. Hog-nosed snakes (*Heterodon*)
    C2: Rostral not turned up or keeled above.
      D1: Head with usual scale arrangement: loreal, preoculars, and two internasals.
        E1: Scales in 17 rows.
          F1: Uniform green above. Found from Connecticut to Florida, thence westward through Texas to eastern New Mexico; northward through the Mississippi Valley to Kansas in the west and Ohio in the east.
            5. Rough-scaled green snake (*Opheodrys*)
          F2: Dark above with a light spot on each scale. Found only in extreme southern Texas.
            6. Speckled ground snake (*Drymobius*)
        E2: Scales in more than 17 rows.
          F1: Scales strongly keeled; 3 postoculars or, if only two, scales in 19, occasionally 23 rows. Not found west of New Mexico, Colorado, Nebraska, and the Dakotas.
            7. Water snakes (*Natrix*)
          F2: Scales weakly keeled, in 25 to 33 rows; 2 postoculars. Not

found in Pacific and far northwestern states. 8. Elaphes (*Elaphe*)

D2: Some of usual head scales lacking.

E1: Loreal absent (Fig. 13). Not found in Pacific and other far western states. 9. Storer's snakes (*Storeria*)

E2: Loreal present.

F1: A single internasal (Fig. 15).

G1: Belly without markings; 5 upper labials; a single postocular (Fig. 14). Found from Virginia to northern Florida; westward to central Texas, Oklahoma, and Missouri. 10. Ground snake (*Potamophis*)

G2: Belly conspicuously mottled; more than 5 upper labials; 2 postoculars. Found from Virginia southward to Florida, thence westward to Texas and up the Mississippi Valley to Indiana. 11. Horn snake (*Farancia*)

F2: 2 internasals (Fig. 16).

G1: 7 upper labials. Found in coastal regions from Virginia southward through Florida to Alabama. 12. Rainbow snake (*Abastor*)

G2: 6 upper labials; usually 2 postoculars. Found from New Jersey westward to Iowa; southward through Georgia and to central Texas. 13. Gray snake (*Virginia*)

G3: 5 upper labials; a single postocular. 10. Ground snake (*Potamophis*)

B2: Anal entire (Fig. 6).

C1: Scales in 29 to 35 rows. Not found in Michigan, New York, or New England. 14. Pine and bull snakes (*Pituophis*)

C2: Scales in 23 or fewer rows.

D1: Eye in contact with upper labials; rostral normal.

E1: Upper labials 5. 10. Ground snake (*Potamophis*)

E2: Upper labials more than 5. Found throughout United States. 15. Garter snakes (*Thamnophis*)

D2: Eye separated from upper labials by small scales; rostral large, in contact with prefrontals. Found only in extreme southwestern United States. 16. Leaf-nosed snakes (*Phyllorhynchus*)

A2: Scales of back without a median keel (smooth).

B1: Anal entire (Fig. 6).

C1: Eye separated from upper labials by small scales; rostral large, in contact with prefrontals. 16. Leaf-nosed snakes (*Phyllorhynchus*)

C2: Eye in contact with upper labials; rostral normal.

D1: More rows of scales at middle than at posterior end of body.

E1: Many of subcaudal plates entire. Found southward from southern Idaho through California; eastward to Kansas and central Texas. 17. LONG-NOSED SNAKE (*Rhinocheilus*)

E2: None or rarely only a few of subcaudal plates entire.

F1: Pupil vertically elliptic; 2 or 3 loreals (Fig. 20). Found in southern Utah and southern Nevada southward through California and Arizona; also in the extreme western tip of Texas. 18. LYRE SNAKES (*Trimorphodon*)

F2: Pupil round; loreal, if present, single.

G1: Belly never entirely without markings; rostral not prominent. Not found from northern Minnesota westward through Washington.

19. KING SNAKES (*Lampropeltis*)

G2: Belly light, devoid of markings; rostral prominent. Found from southwestern Kansas southward through central Texas; westward through southern California.

20. FADED SNAKE (*Arizona*)

D2: Same number of scale rows at middle as at posterior end of body.

E1: Scales in 17 rows. Found from South Carolina southward through Florida, thence westward to southern Louisiana; southern Texas.

21. INDIGO SNAKE AND MEXICAN RAT SNAKE (*Drymarchon*)

E2: Scales in 19 rows.

F1: Loreal present; parietal not in contact with upper labials. Found from Louisiana and eastern Oklahoma eastward through Florida and North Carolina, thence northeastward to southern New Jersey.

22. SCARLET SNAKE (*Cemophora*)

F2: Loreal absent; parietal in contact with upper labial. Found only in central and northern Florida.

23. SHORT-TAILED SNAKE (*Stilosoma*)

B2: Anal divided (Fig. 7).

C1: Scales in 25 or more rows. 8. ELAPHES (*Elaphe*)

C2: Scales in 19 to 23 rows.

D1: 2 internasals.

E1: One or more preoculars.

F1: Pupil of eye round; a single preocular. Found only in extreme southern Texas.

24. BLACK-BANDED SNAKE (*Coniophanes*)

F2: Pupil vertically elliptic; 2 or 3 preoculars.

G1: One loreal.

H1: Lateral spots alternating with dorsal blotches. Found from central Texas northwestward and westward to southern Idaho and through central and southern California. 25. SPOTTED NIGHT SNAKE (*Hypsiglena*)

H2: More or less confluent dorsal blotches, no lateral spots. Found only in extreme southern Texas. 26. ANNULATED SNAKE (*Leptodeira*)

G2: 2 or 3 loreals. 18. LYRE SNAKES (*Trimorphodon*)

E2: Preocular absent. 12. RAINBOW SNAKE (*Abastor*)

D2: A single internasal.

E1: Preocular present. Found only in Florida and southern Georgia. 27. ALLEN'S SNAKE (*Liodytes*)

E2: Preocular absent. 11. HORN SNAKE (*Farancia*)

C3: Scales in fewer than 19 rows.

D1: Loreal present.

E1: 2 or 3 preoculars.

F1: Rostral widened laterally and extended backward over snout (Fig. 22). Found from southern California eastward through nearly all of Texas; northward into southern and western Nevada and extreme southwestern Utah. 28. PATCH-NOSED SNAKE (*Salvadora*)

F2: Rostral normal.

G1: Usually 2 or 3 anterior temporals; lower preocular small, wedged between upper labials (Fig. 2). Widely distributed. 29. RACERS AND WHIP SNAKES (*Coluber*)

G2: A single anterior temporal; lower preocular moderate in size, not wedged between upper labials.

H1: Back and sides uniform grass-green, no band on neck. Found from Utah, New Mexico, and Texas northeastward to North Dakota and Illinois, thence eastward through New Jersey and through New England. 30. SMOOTH-SCALED GREEN SNAKE (*Entechinus*)

H2: Back and sides not uniform grass-green, usually a conspicuous narrow band across neck. Widely distributed. 31. RING-NECKED SNAKES (*Diadophis*)

E2: A single preocular.

F1: Scales in 17 rows.

G1: 7 upper labials; a dark line from rostral through eye to middle of last upper labial. Found from eastern North Carolina southward to Florida, thence westward to eastern Texas. 32. YELLOW-LIPPED SNAKE (*Rhadinaea*)

G2: Usually 8 upper labials; no line from rostral to last upper labial. Found from eastern North Carolina southward through Florida.
33. BLACK SWAMP SNAKE (*Seminatrix*)

F2: Scales in fewer than 17 rows.

G1: Back and sides grass-green.
30. SMOOTH-SCALED GREEN SNAKE (*Entechinus*)

G2: Back and sides not grass-green.

H1: Ventral plates with black anterior borders. Found only in the Pacific states but absent from extreme southern California. 34. SHARP-TAILED SNAKE (*Contia*)

H2: Belly uniformly light or crossed by dark bands that encircle the body. Found from Texas westward to southern California; northward to southern Kansas, central Colorado and southern Idaho.
35. WESTERN GROUND SNAKES (*Sonora*)

E3: No preocular.

F1: Scales in 15 or 17 rows; 6 upper labials.
13. GRAY SNAKE (*Virginia*)

F2: Scales in 13 rows; 5 upper labials. Found from southeastern Nebraska and eastern Texas eastward to Florida and Connecticut. 36. WORM-SNAKE (*Carphophis*)

D2: No loreal.

E1: Scales in 13 rows; light above with black cross-bars. Found only in southern Arizona and rarely in extreme southeastern California.
37. BANDED BURROWING SNAKE (*Chilomeniscus*)

E2: Scales in more than 13 rows.

F1: Scales in 17 rows; rostral peculiar.

G1: Tail short and thick, not nearly half as long as body. Found from southern and western Texas westward to Arizona. 38. HOOK-NOSED SNAKE (*Ficimia*)

G2: Tail very long and slender, more than half as long as body. Found only in extreme southern Arizona.
39. ARIZONA LONG-HEADED SNAKE (*Oxybelis*)

F2: Scales in 15 rows; rostral normal.

G1: Uniformly colored above except on or near head. Found only in the southern half of the United States.

40. Black-headed snakes (*Tantilla*)

G2: Gaudily ringed with black, yellow, and red (illustration facing p. 150); highly poisonous, rigid poison fangs in front of upper jaw.

H1: Yellow head-band covers most of parietals and is followed by a broad black band. Found from North Carolina southward through Florida, thence westward to extreme southeastern Oklahoma and through eastern and southeastern Texas; up the Mississippi and Ohio Valleys to southern Indiana.

41. Coral snake (*Micrurus*)

H2: Yellow head-band covers only posterior part of parietals and is followed by a broad red band. Found only in southern Arizona.

42. Sonoran coral snake (*Micruroides*)

GROUP IV. PIT-VIPERS. FAMILY CROTALIDAE. POISONOUS.

The possession of a deep cavity, the pit (Fig. 28), between eye and nostril immediately identifies one of these snakes. Long movable hollow fangs are present in the front of the upper jaw and the broad head is quite distinct from the neck. A rattle is present on the end of the tail in all but two species: the water moccasin and the copperhead. The ventral plates are well developed.

A1: A rattle on end of tail.

B1: Crown of head to well back of eyes covered by a few large symmetrical scales (Fig. 26). Widely distributed over the United States east of a line connecting Tucson, southeastern Arizona, with St. Paul, eastern Minnesota, but not found from Virginia northeastward to Maine. 43. Pygmy rattlesnakes (*Sistrurus*)

B2: Crown of head between the eyes covered by a pair of large scales (the supraoculars) and numerous small irregular ones between the supraoculars (Fig. 27). Not found in Michigan.

44. Rattlesnakes (*Crotalus*)

A2: No rattle on end of tail. Found throughout the southeastern United States westward through Texas and from central Kansas northeastward to New York and Massachusetts.

45. Copperhead and water moccasin (*Agkistrodon*)

LIST OF GENERA AND SPECIES OF SNAKES OF UNITED STATES

1. Blind snakes (*Leptotyphlops*).

Texas blind snake (*L. dulcis*). The scale covering one eye is separated from its fellow covering the other eye by three scales. Texas, Oklahoma, and New Mexico.

Garman's blind snake (*L. myopica*). The scale covering one eye is separated from its fellow by three scales. Southern New Mexico.

California blind snake (*L. humilis*). The scale covering one eye is separated from its fellow by a single scale. Two subspecies of this form exist, one (*humilis*) found in southern California west of the desert, the other (*cahuilae*) confined to the deserts of southeastern California and western Arizona.

2. Rubber snake (*Charina*).

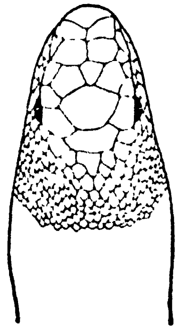


FIG. 8
Rubber snake,
top of head.

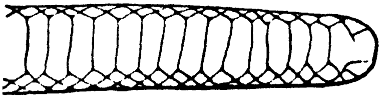


FIG. 9
Rubber snake, under side of tail.

Rubber snake (*C. bottae*). Fig. 8. The tail of this species is very blunt (Fig. 9). Utah, Wyoming, and Montana westward and southwestward to the Pacific coast.

3. California boa (*Lichanura*).

California boa (*L. roseofusca*). The tail is only moderately blunt. Two subspecies are recognized, one (*roseofusca*) confined to extreme southwestern California, the other (*gracia*) found in the desert regions of southeastern California and southwestern Arizona.

4. Hog-nosed snakes (*Heterodon*).

Key to Species

A1: Prefrontals in contact.
  B1: Internasals separated by a small scale (Fig. 10).
    Common hog-nosed snake

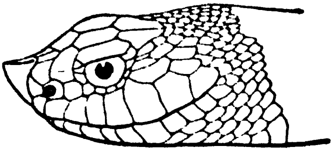


FIG. 10
Common hog-nosed snake, side and top of head.

  B2: Internasals in contact (southern Florida).
    Brown's hog-nosed snake
A2: Prefrontals separated by small scales and often reduced.
  B1: Scales in 23 rows. Western hog-nosed snake
  B2: Scales in 25, rarely 27 rows. Southern hog-nosed snake

Common hog-nosed snake (*H. contortrix*). Fig. 10 and illustrations facing page 84. Massachusetts southward to central Florida; westward to central Texas, through Kansas and to eastern Montana.

Brown's hog-nosed snake (*H. browni*). Southern Florida.

Western hog-nosed snake (*H. nasicus*). Montana southeastward to western Iowa; southward through Texas, New Mexico, and Arizona.

Southern hog-nosed snake (*H. simus*). Southeastern states; northwestward to southern Indiana.

5. Rough-scaled green snake (*Opheodrys*).

Rough-scaled green snake (*O. aestivus*). Semi-arboreal species. Connecticut to Florida, thence westward through Texas to eastern New Mexico; northward through the Mississippi Valley to Kansas in the west and Ohio in the east. Exceedingly rare from central New Jersey to Connecticut.

6. Speckled ground snake (*Drymobius*).

Speckled ground snake (*D. margaritiferus*). Extreme southern Texas.

7. Water snakes (*Natrix*). The pattern in adult snakes of this genus is often obscure. In such cases distributions must be relied on if wetting or looking at the specimen while holding it under water fails to bring out the pattern.

Key to Species

- A1: Back with longitudinal stripes; scales in 19 to 21 rows.
  - B1: Scales in 19 rows.
    - C1: 2 dark stripes present at least anteriorly along middle of belly.
      - D1: A light stripe along lower side. Queen snake
      - D2: No light stripe along lower side (South Carolina to northern Florida, thence westward to Louisiana). Rigid queen snake
    - C2: Middle of belly plain or with a single dark stripe. Graham's water snake
  - B2: Scales in 21 rows (coastal region of southeastern United States from northwestern Florida westward through Texas). Clark's water snake
- A2: Back with cross-bands or spots.
  - B1: Scales in 19 to 21 rows.
    - C1: Scales in 19 rows. Kirtland's water snake
    - C2: Scales in 21 rows (coastal parts of peninsular Florida, chiefly the western side). Flat-tailed water snake
  - B2: Scales in 23 to 33 rows.
    - C1: Scales in 23 to 25 rows.
      - D1: Belly largely uniform yellow or red, never with half-moon-shaped spots; under side of tail not darker than belly. Red-bellied water snake
      - D2: Belly usually with numerous half-moon-shaped red or brown spots, never uniform red; under side of tail darker than belly. Common water snake
    - C2: Scales in 27 (rarely 25) to 33 rows.
      - D1: 2 anterior temporals; square isolated spots of back alternating with a series of lateral spots. Water pilot
      - D2: A single anterior temporal; dorsal spots connected with lateral ones.
        - E1: Eye in contact with upper labials; conspicuous diamond-shaped spots along back. Diamond-backed water snake
        - E2: Eye separated from upper labials by small scales (Fig. 11);

spots along back less distinct, not diamond-shaped.
GREEN WATER SNAKE

A3: Back uniform; scales in 23 to 25 rows; belly largely uniform yellow or red.
RED-BELLIED WATER SNAKE

QUEEN SNAKE (*N. septemvittata*). Extreme west-central New Jersey westward through Pennsylvania and southern Michigan to southeastern Wisconsin; southward through the elevated parts of southeastern United States but absent from the coastal plain.

RIGID QUEEN SNAKE (*N. rigida*). South Carolina to northern Florida, thence westward to Louisiana.

GRAHAM'S WATER SNAKE (*N. grahamii*). Illinois westward to eastern Kansas; southward through Louisiana and eastern Texas.

CLARK'S WATER SNAKE (*N. clarkii*). Coastal region of southeastern United States from northwestern Florida through Texas.

KIRTLAND'S WATER SNAKE (*N. kirtlandii*). Western Pennsylvania westward to central Illinois; northward to southern Michigan and southern Wisconsin; one New Jersey record.

FLAT-TAILED WATER SNAKE (*N. compressicauda*). Coastal parts of peninsular Florida, chiefly the western side.

RED-BELLIED WATER SNAKE (*N. erythrogaster*). Widely distributed in south-central and eastern United States from eastern New Mexico through Texas and Kansas eastward and as far north as southern Michigan. Although common in the western part of its range (subspecies *transversa*), this snake is exceedingly rare in the eastern states (subspecies *erythrogaster*) where it occurs in only a few widely separated colonies. In the east it has long been hopelessly confused with the ubiquitous common water snake.

COMMON WATER SNAKE (*N. sipedon*). Illustrations facing page 33. Snake is divided into several subspecies, the ranges of which have not as yet been clearly defined. In general they are: a northern one (*sipedon*) distributed from southern Maine westward to Minnesota, thence to Colorado and southward in the east to northern Alabama; a southeastern one (*fasciata*) occupying the territory south of the range of the preceding and eastward from the Mississippi Valley except peninsular Florida where a third subspecies (*pictiventris*) occurs; a fourth (*confluens*) found from the Mississippi Valley region westward into Texas, Oklahoma, and Kansas and northward to meet the northern subspecies.

WATER PILOT (*N. taxispilota*). Eastern Virginia southward through Florida, thence westward to Louisiana.

DIAMOND-BACKED WATER SNAKE (*N. rhombifera*). Illus. facing page 150. Indiana and Illinois southward to Alabama and through Texas.

Green water snake (*N. cyclopion*). Fig. 11. Two subspecies of this snake have been recognized recently: one (*floridana*) is found throughout Florida, in southern Georgia and coastal South Carolina; the other (*cyclopion*) occurs from southern Indiana southward throughout Louisiana and eastward to Alabama. It may occur in eastern Texas too.

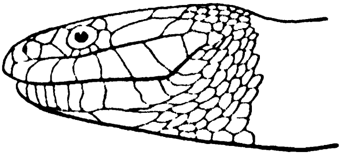


FIG. 11
Green water snake,
side of head.

8. Elaphes (*Elaphe*).

Key to Species

A1: Eye separated from upper labials by small scales (extreme western Texas). **Davis Mountains rat snake**

A2: Eye in contact with upper labials.
  B1: Uniform grayish or greenish above, whitish beneath (extreme southeastern Arizona). **Mexican green rat snake**
  B2: Dark brown or black or with blotches or stripes above, belly usually with dark markings.
    C1: 50 or more narrow, dark, widely separated dorsal cross-bands (extreme western Texas). **Baird's rat snake**
    C2: Not with 50 or more such cross-bands.
      D1: A pair of longitudinal bands from neck converging across parietals to meet on frontal.
        E1: Dorsal blotches grayish or light brown. **Texas rat snake**
        E2: Dorsal blotches reddish.
          F1: Belly yellowish, conspicuously checkered with black. **Corn snake**
          F2: Belly pinkish with little or no black (Florida Keys). **Rosy rat snake**
      D2: No converging bands from neck meeting on frontal.
        E1: Dorsal blotches squarish, without forward and backward projections at corners. **Fox snake**
        E2: Dorsal blotches, if present, squarish, mostly with forward and backward projections at corners.

F1: Adult with 4 longitudinal stripes, young blotched.
FOUR-LINED RAT SNAKE

F2: Adult without longitudinal stripes.

  G1: Adult nearly or quite uniform black above, young blotched. PILOT BLACK SNAKE

  G2: Both adult and young blotched.
  BLOTCHED RAT SNAKE

DAVIS MOUNTAINS RAT SNAKE (*E. subocularis*). Extreme western Texas.

MEXICAN GREEN RAT SNAKE (*E. chlorosoma*). Extreme southeastern Arizona.

BAIRD'S RAT SNAKE (*E. bairdi*). Extreme western Texas.

TEXAS RAT SNAKE (*E. laeta*). All the scales of this snake are smooth or those of only a few dorsal rows have keels. Southern New Mexico through Texas to western Arkansas; northward to eastern Nebraska.

CORN SNAKE (*E. guttata*). All the scales are smooth or those of only a few dorsal rows have keels. Southern New Jersey through Florida, thence westward to Louisiana and Missouri.

ROSY RAT SNAKE (*E. rosacea*). All the scales are smooth or those of only a few dorsal rows have keels. Florida Keys.

FOX SNAKE (*E. vulpina*). Ohio westward through Iowa to southeastern South Dakota; northward to Minnesota and through Wisconsin and Michigan.

FOUR-LINED RAT SNAKE (*E. quadrivittata*). This and the following species are blotched when young and therefore one is easily confused with another. Eastern North Carolina southward throughout Florida, thence westward to Louisiana and Mississippi. Specimens from the Upper Florida Keys are sometimes set off as a subspecies (*deckerti*).

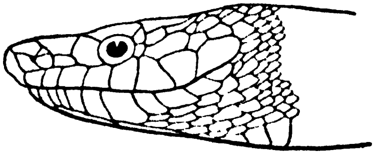


FIG. 12
Pilot black snake, side of head.

PILOT BLACK SNAKE (*E. obsoleta*). Fig. 12. Massachusetts westward to Wisconsin; southward to Georgia and eastern Texas.

BLOTCHED RAT SNAKE (*E. confinis*). This snake is usually considered a subspecies of the pilot black snake. North Carolina southward to Florida, thence westward through eastern Texas; up the Mississippi Valley to Indiana.

9. Storer's snakes (*Storeria*).

Key to Species

A1: Scales in 17 rows. DeKay's snake

A2: Scales in 15 rows.

B1: Belly reddish, without spots; dorsal color usually extending well onto ends of ventrals; upper labials 6, rarely 7. Red-bellied snake

B2: Belly pale with a double row of small dark spots; dorsal color extending only slightly onto ventrals; 7 upper labials (Florida and southeastern Georgia). Hay's snake

DeKay's snake (*S. dekayi*). Maine westward to Minnesota; southward through Texas and to northern Florida.

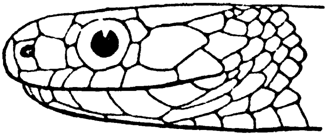


FIG. 13
Red-bellied snake,
side of head.

Red-bellied snake (*S. occipito-maculata*). Fig. 13. Maine southward through Alabama and Georgia to central Florida; westward and southwestward from Maine to South Dakota and eastern Texas. This snake avoids much of the low coastal and Mississippi Valley region of the south.

Hay's snake (*S. victa*). Florida and southeastern Georgia.

10. Ground snake (*Potamophis*).

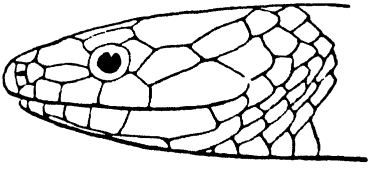


FIG. 14
Ground snake,
side of head.

Ground snake (*P. striatulus*). Fig. 14. Virginia to northern Florida; westward to central Texas, Oklahoma, and Missouri.

11. Horn snake (*Farancia*).

Horn snake (*F. abacura*). Fig. 15, illustrations facing p. 85. This species is dark above without spots or stripes but the belly is brilliantly marked with red, which usually extends onto the lowermost scale rows at regular intervals. Virginia southward to Florida, thence westward to Texas and up the Mississippi Valley to Indiana.

12. Rainbow snake (*Abastor*).

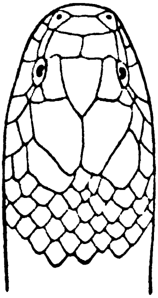


FIG. 15
Horn snake,
top of head.

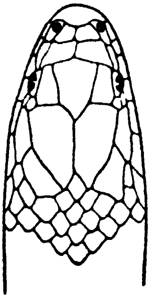


FIG. 16
Rainbow snake,
top of head.

Rainbow snake (*A. erythrogrammus*). Fig. 16. This snake is brown above with a light stripe along either side and with rows of dark spots on the belly. Coastal regions from Virginia southward through Florida to Alabama.

13. Gray snake (*Virginia*).

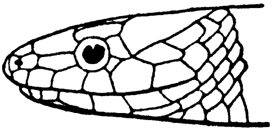


FIG. 17
Gray snake,
side of head.

Gray snake (*V. valeriae*). Fig. 17. Two subspecies of this snake are recognized, one (*valeriae*) found from Georgia and northern Alabama northeastward to southern Ohio and northern New Jersey, the other (*elegans*) from central Texas eastward to southwestern Alabama and northward to Iowa, Illinois, and Indiana, thence across Ohio to western Pennsylvania.

14. **PINE AND BULL SNAKES** (*Pituophis*). Extremely valuable to agriculture.

KEY TO SPECIES

A1: Rostral penetrating well between internasals and conspicuously higher than wide (Fig. 18).
  B1: Dorsal spots evident.
    C1: 35 or fewer dorsal spots. PINE SNAKE
    C2: 40 or more dorsal spots. BULL SNAKE
  B2: Dorsal spots absent or obscured by mottling.
    C1: Profusely mottled with brown (Florida). FLORIDA PINE SNAKE
    C2: Uniform black above and below (southwestern Alabama). LÖDING'S PINE SNAKE
A2: Rostral not or but slightly penetrating between internasals, about as high as wide (Fig. 19). PACIFIC BULL SNAKE

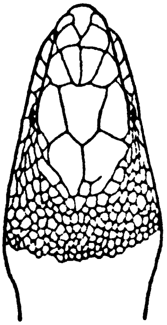


FIG. 18
Bull snake,
top of head.

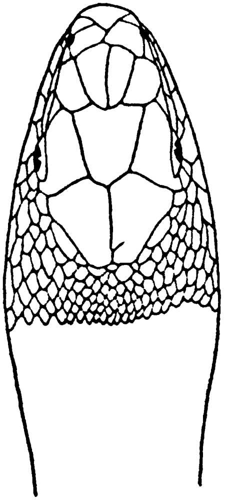


FIG. 19
Pacific bull snake, top of head.

PINE SNAKE (*P. melanoleucus*). Illus. facing page 90. This snake seems to be abundant only in the pine barrens of southern New Jersey. It has also been found in Virginia, West Virginia, North and South Carolina, and eastern Tennessee but its occurrence is decidedly erratic.

BULL SNAKE (*P. sayi*). Fig. 18, illustration facing page 132. Two subspecies of this snake are recognized, one (*sayi*) ranging widely throughout the great plains region of central United States, the other (*affinis*) occurring from Colorado southward and southwestward through New Mexico and Arizona and to California.

FLORIDA PINE SNAKE (*P. mugitus*). Florida.

LÖDING'S PINE SNAKE (*P. lödingi*). Mobile County, southwestern Alabama.

PACIFIC BULL SNAKE (*P. catenifer*). Fig. 19. Three subspecies are recognized: the true Pacific bull snake (*catenifer*) of the Pacific states except the coastal region of California south of San Pablo Bay where another subspecies (*annectans*) occurs; the desert gopher snake (*deserticola*) found from the eastern desert regions of California eastward to western Colorado and northward to Idaho and eastern Oregon and Washington.

15. GARTER SNAKES (*Thamnophis*). These are the most commonly met with of all our snakes. Their pattern is predominantly a striped one. The identification of species is often difficult, so special attention should be paid to distributions.

KEY TO SPECIES

A1: Lateral stripe anteriorly on third and fourth rows of scales above ventral plates.
  B1: Tail usually more than a quarter of the total length; body slender. RIBBON SNAKE
  B2: Tail usually less than a quarter of the total length; body moderately stout.
    C1: 8 or 9 upper labials (extreme southwestern Texas to southern Arizona). MEXICAN GARTER SNAKE
    C2: Usually fewer than 8 upper labials.
      D1: Scales usually in 21 rows; 7, occasionally 8 upper labials. PLAINS GARTER SNAKE
      D2: Scales usually in 19 rows; 6 or 7 upper labials. BUTLER'S GARTER SNAKE
A2: Lateral stripe anteriorly not involving fourth row of scales, or absent.
  B1: Lateral stripe on third row only. MARCY'S GARTER SNAKE
  B2: Lateral stripe anteriorly on second and third rows, or absent.
    C1: Normally 7 upper labials.
      D1: Scales usually in 17 rows; chin-shields of posterior pair about as long as those of anterior pair (Pacific coastal region southward through northern California). WESTERN GARTER SNAKE (subspecies *ordinoides*)

D2: Scales in 19 rows; chin-shields of posterior pair much longer than those of anterior. COMMON GARTER SNAKE

C2: Normally 8 upper labials.

D1: Scales usually in 19 or fewer rows.

E1: Chin-shields of posterior pair longer than those of anterior pair (Arizona and southern Utah southeastward into Texas). WHITE-BELLIED GARTER SNAKE

E2: Chin-shields of posterior pair about as long as those of anterior (coastal region of central and south-central California). WESTERN GARTER SNAKE (subspecies *atratus*)

D2: Scales usually in more than 19 rows.

E1: Some stripes usually present. WESTERN GARTER SNAKE

E2: All stripes usually absent, dorsal spots very numerous and prominent (southern Arizona and southwestern New Mexico). BROWN-SPOTTED GARTER SNAKE

C3: 5 or 6 upper labials. STRIPED SWAMP SNAKE

RIBBON SNAKE (*T. sauritus*). The ribbon snake is divided into three subspecies: a western one (*proximus*) found from Nebraska and Wisconsin southward through Texas and Louisiana; a southern one (*sackenii*) ranging through Florida and adjacent coastal parts of other extreme southeastern states; and an eastern form (*sauritus*) generally distributed over the United States east and north of the ranges of the other two and reaching Maine.

MEXICAN GARTER SNAKE (*T. megalops*). Extreme southwestern Texas to southern Arizona.

PLAINS GARTER SNAKE (*T. radix*). Wisconsin, Illinois, and Missouri westward through the great plains region of north-central United States.

BUTLER'S GARTER SNAKE (*T. butleri*). Extreme western New York and western Pennsylvania westward through Ohio, Indiana, and southern Michigan to southeastern Wisconsin.

MARCY'S GARTER SNAKE (*T. marcianus*). Extreme southwestern Kansas southward through western Oklahoma to extreme southern Texas, thence northwestward to southeastern California.

WESTERN GARTER SNAKE (*T. ordinoides*). Six or seven subspecies of this snake are recognized, all found in the Pacific and other extreme western states.

COMMON GARTER SNAKE (*T. sirtalis*). Illus. facing page 33. This snake inhabits almost the entire United States. Four subspecies are recognized: an eastern one (*sirtalis*) found as far west as Minnesota, Missouri, southeastern Oklahoma, and eastern Texas; two extreme western ones, the first (*concinnus*) confined chiefly to the coastal regions of Washington, Oregon, and northern California, the second (*infernalis*) ranging over southern Oregon, western Nevada, and most of California; a central form (*parietalis*) widely distributed over the vast region between the eastern and the second extreme western subspecies except for much of the area between southeastern California and eastern Texas.

White-bellied garter snake (*T. eques*). Arizona and southern Utah southeastward into Texas.

Brown-spotted garter snake (*T. angustirostris*). Southern Arizona and southwestern New Mexico.

Striped swamp snake (*T. lineatus;* often called *Tropidoclonion lineatum*). Ohio southwestward to Tennessee and central Texas, thence northward to southeastern South Dakota.

16. Leaf-nosed snakes (*Phyllorhynchus*). The scales may be smooth or keeled.

Leaf-nosed snake (*P. decurtatus*). This species always has more than 18 blotches along the back anterior to the tail. Two subspecies are recognized, one (*decurtatus*) from south-central Arizona, the other (*perkinsi*) from southern Nevada, western Arizona, and arid parts of southern California.

Brown's leaf-nosed snake (*P. browni*). This rare species always has fewer than 16 dorsal blotches anterior to the tail. South-central Arizona.

17. Long-nosed snake (*Rhinocheilus*).

Long-nosed snake (*R. lecontei*). Numerous undivided plates under the tail distinguish this snake from all others of Group III. Southward from southern Idaho through California; eastward to Kansas and central Texas.

18. Lyre snakes (*Trimorphodon*). The vertically elliptic pupil distinguishes these snakes from all others of Group III except the annulated and spotted night snakes.

Wilkinson's lyre snake (*T. vilkinsonii*). The anal is divided. There is but one record of this Mexican snake in the United States; a specimen was taken in the extreme western tip of Texas.

Lyre snake (*T. lyrophanes*). Fig. 20. The anal is usually divided, the dorsal spots number 21 to 33. Arizona and southern Utah.

California lyre snake (*T. vandenburghi*). The anal is usually entire, the dorsal spots number 30 to 42. Southern Nevada southwestward through southern California.

19. KING SNAKES (*Lampropeltis*). Species of this genus are largely separated by differences in their complex color patterns, so I have partly relied on geography in the key to avoid making it too long and involved.

KEY TO SPECIES

A1: Back with narrow black cross-bands on a slate-gray ground color, the alternate cross-bands mixed or split with red (extreme western Texas). DAVIS MOUNTAINS KING SNAKE

A2: Back without such a pattern.

- B1: No red in pattern and no black-bordered brown or gray blotches on back. COMMON KING SNAKE
- B2: Red in pattern or back with black-bordered brown or gray blotches.
  - C1: Back with brownish or dark red black-edged blotches that do not extend downward on the sides to the fifth row of scales above the ventral plates or else make very narrow contacts with this row.
    - D1: Scales in 25 or 27 rows; dorsal blotches concave in front and behind. YELLOW-BELLIED KING SNAKE
    - D2: Scales in 21 or 23 rows; dorsal blotches straight or convex in front and behind. BROWN KING SNAKE
  - C2: Body ringed or back with brown, red, or gray blotches that make broad contact with the fifth or a lower row of scales.
    - D1: More than 40 whitish cross-bands on body and tail (illustration facing p. 150); top of head black, snout uniformly white (Utah southward through Arizona and western New Mexico). ARIZONA KING SNAKE
    - D2: Fewer than 40 whitish cross-bands on body and tail or, if more than 40, snout not uniformly whitish.
      - E1: California. Ringed with black and white, the black rings more or less split with red. MOUNTAIN KING SNAKE
      - E2: Eastward from Utah to South Dakota, through Minnesota and Illinois to Delaware and Maine; eastward from Arizona through Mississippi and western Tennessee. MILK SNAKE
      - E3: From Delaware westward to Kentucky; southward through Florida and the Mississippi Delta.

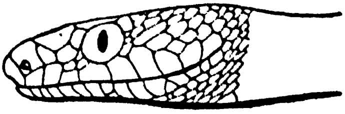


FIG. 20
Lyre snake,
side of head.

F1: Usually 2 anterior temporals; back with brown, gray, or red black-edged blotches never reaching ventral plates; belly checkered with black and white, sometimes suffused with red. Exceedingly rare in or absent from coastal plain of southernmost states, common in mountains. **Milk snake**

F2: Usually a single anterior temporal (Fig. 21); body gaudily adorned with black, red, and yellow or white rings or saddles. Common chiefly in coastal plain of southernmost states. **Scarlet king snake**

Davis Mountains king snake (*L. alterna*). Extreme western Texas.

Common king snake (*L. getulus*). In extreme southern United States the range of this species is continuous from the Atlantic to the Pacific coasts but its eight subspecies differ much in appearance and some of them are found fairly far north. They are distributed as follows:

The common eastern one (*getulus*) (illus. facing page 101) from southern New Jersey southward and southwestward to northern Florida and through southeastern Alabama.

A second (*floridana*) from northern Florida southward to but not through its southeastern tip.

A third (*brooksi*) is found only on the extreme southeastern tip of Florida.

A fourth (*nigra*) from central Alabama northward and northeastward to eastern Illinois, southern Ohio, and western West Virginia.

A fifth (*holbrooki*) from western Alabama westward through Oklahoma and eastern Texas; northward and northwestward through Illinois and to southeastern Wyoming.

A sixth (*splendida*) from southwestern Oklahoma and central Texas westward to southeastern Arizona.

A seventh (*yumensis*) from extreme southeastern California eastward through most of southern Arizona.

An eighth (*californiae*), which may be either cross-banded or have a narrow stripe down the middle of its back, from southern Oregon southward through California; eastward through southern Nevada to southwestern Utah and over all of Arizona but the southern and eastern parts.

Yellow-bellied king snake (*L. calligaster*). From Mississippi, western Indiana, and southern Minnesota southward and westward through Texas.

Brown king snake (*L. rhombomaculata*). From Maryland southward and southwestward to southwestern Alabama and central Florida.

ARIZONA KING SNAKE (*L. pyromelana*). Illus. facing page 150. Utah southward through Arizona and western New Mexico.

MOUNTAIN KING SNAKE (*L. zonata*, formerly known as *L. multicincta*). California, except in deserts.

MILK SNAKE (*L. triangulum*). As shown by the key this species is distributed from Arizona, Utah, and South Dakota eastward to the Atlantic coast. Its subspecies differ considerably in appearance and are distributed as follows:

One (*gentilis*) from Utah and Arizona southeastward through western and central Texas, thence northward to South Dakota.

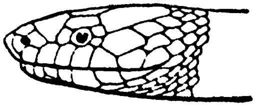
The second (*annulata*) is found only in extreme southern Texas.

The third (*amaura*) from eastern Texas and southeastern Oklahoma eastward through the lower Mississippi Valley.

The fourth (*syspila*) from northeastern Oklahoma eastward to western Tennessee; northward to southern Indiana, southern and western Illinois, and southern Minnesota.

The fifth (*triangulum*) (illus. facing page 104) from the ranges of the two preceding subspecies eastward to the coast; common in the northeast and in the mountains of the southern states but rare in or absent from the low country of the south.

FIG. 21
Scarlet king snake,
side of head.



SCARLET KING SNAKE (*L. elapsoides*). Fig. 21. This species is divided into two subspecies, one (*elapsoides*) found from Kentucky and North Carolina southward to the Mississippi Delta and throughout Florida; the other (*virginiana*) known from northern North Carolina northward to Delaware.

20. FADED SNAKE (*Arizona*).

FADED SNAKE (*A. elegans*). The high scale count of this snake (27 to 31 rows) will help to identify it. Two subspecies are recognized: one (*elegans*) ranging from southwestern Kansas southward through central Texas; westward to southeastern Arizona; the other (*occidentalis*) from southeastern Arizona westward through southern California.

21. INDIGO SNAKE AND MEXICAN RAT SNAKE (*Drymarchon*).

INDIGO SNAKE AND MEXICAN RAT SNAKE (*D. corais*). Both of the subspecies of this handsome snake have a common name: The indigo snake (*couperi*) is almost entirely black above and below (illus. facing page 132) and ranges from South Carolina southward through Florida, thence westward to southern Louisiana; the Mexican rat snake (*melanurus*) occurs only in southwestern Texas and is light anteriorly, black posteriorly.

22. SCARLET SNAKE (*Cemophora*).
SCARLET SNAKE (*C. coccinea*). Brilliant bands of scarlet, black, and yellow make this snake resemble the deadly coral snakes but in the scarlet snake the bands do not encircle the body as do the areas of similar but somewhat differently arranged colors of the coral snakes. Louisiana and eastern Oklahoma eastward through Florida and North Carolina, thence northeastward to southern New Jersey.

23. SHORT-TAILED SNAKE (*Stilosoma*).
SHORT-TAILED SNAKE (*S. extenuatum*). Central and northern Florida.

24. BLACK-BANDED SNAKE (*Coniophanes*).
BLACK-BANDED SNAKE (*C. imperalis*). Extreme southern Texas.

25. SPOTTED NIGHT SNAKE (*Hypsiglena*).
SPOTTED NIGHT SNAKE (*H. ochrorhynchus*). The vertically elliptic pupil distinguishes this snake from all others of Group III except the annulated and lyre snakes. Central Texas northwestward and westward to southern Idaho and through central and southern California.

26. ANNULATED SNAKE (*Leptodeira*).
ANNULATED SNAKE (*L. septentrionalis*). The vertically elliptic pupil distinguishes this snake from all others of Group III except the spotted night and lyre snakes. Extreme southern Texas.

27. ALLEN'S SNAKE (*Liodytes*).
ALLEN'S SNAKE (*L. alleni*). Florida and southern Georgia.

28. PATCH-NOSED SNAKE (*Salvadora*).
PATCH-NOSED SNAKE (*S. grahamiae*). Fig. 22. Three subspecies of this snake have been diagnosed: one (*grahamiae*) is distributed from extreme southeastern Arizona eastward through New Mexico and all of Texas but its extreme eastern part; another (*hexalepis*) is found northwestward from the range of the preceding subspecies through southern and western Arizona, extreme southwestern Utah, southern and western Nevada into south-

eastern California; a third (*virgultea*) is confined to the coastal region of southwestern California.

29. Racers and whip snakes (*Coluber*).

Key to Species

A1: Longitudinal stripes if present only faintly evident on sides of neck.
  B1: Scales in 15 rows at posterior end of body; young blotched, adult uniformly colored above. Blacksnake, blue racer and yellow-bellied racer
  B2: Scales in 11 to 13 rows at posterior end of body; uniform black or brown black above (southeastern Arizona and extreme southern California). Black whip snake
  B3: Scales in 11 to 13 rows at posterior end of body; light brown above, often becoming very dark on head and forebody; dark cross-bands when present on back most conspicuous anteriorly; young always cross-banded. Coachwhip and whip snakes
A2: Continuous or interrupted longitudinal stripes present at least anteriorly along each side of body (except in the uniformly colored adult specimens of the subspecies of the striped racer which is found only in the extreme southern tip of Texas).
  B1: Scales in 15 rows. Striped racer
  B2: Scales in 17 rows.
    C1: One or more dark stripes along each side (southeastern Arizona and extreme southwestern New Mexico). Sonoran racer
    C2: A single light lateral stripe on a very dark ground color (California west of the Sierra Nevada Mountains and the desert). California racer

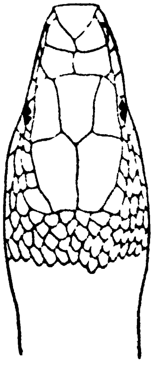


FIG. 22
Patch-nosed snake,
top of head.

BLACKSNAKE (Figs. 1, 2, and 3), BLUE RACER AND YELLOW-BELLIED RACER (*C. constrictor*). Excepting the parts of the United States adjacent to the western Great Lakes and the highest Rocky Mountain area, this snake ranges over the entire country. It is divided into three subspecies: the blacksnake (*constrictor*) found from the Atlantic coast westward to or a little beyond the Mississippi and Ohio Rivers and throughout New York and Pennsylvania; the blue racer (*flaviventris*) inhabiting the region between the range of the blacksnake and the higher Rocky Mountain area; and the yellow-bellied racer (*mormon*) occupying the territory west of the higher Rocky Mountains.

BLACK WHIP SNAKE (*C. piceus*). Southeastern Arizona and extreme southern California.

COACHWHIP AND WHIP SNAKES (*C. flagellum*). This spectacular snake ranges across the southern half of the United States from coast to coast and is divided into three subspecies: the coachwhip (*flagellum*) found from Florida and North Carolina westward to eastern Texas and central Kansas; the western whip snake (*frenatus*) distributed throughout Arizona, much of Utah and Nevada, and most of California; and the whip snake (*flavigularis*) occupying the area between the ranges of the other two.

STRIPED RACER (*C. taeniatus*). Illus. facing page 76. The four subspecies of this snake are distributed as follows: the only widely ranging one (*taeniatus*) is found from southeastern Oregon and southern Idaho southeastward to central Arizona, western New Mexico, and extreme western Texas, and westward to eastern California; a second subspecies (*girardi*) occurs from central to west-central Texas; a third (*ruthveni*) has been taken only in the extreme southern tip of Texas; and a fourth (*schotti*) occupies the part of southern Texas lying between the ranges of the second and third.

SONORAN RACER (*C. semilineatus*). Southeastern Arizona and extreme southwestern New Mexico.

CALIFORNIA RACER (*C. lateralis*). Illus. facing page 101. California west of the Sierra Nevada Mountains and the desert.

30. SMOOTH-SCALED GREEN SNAKE (*Entechinus,* formerly known as *Liopeltis*).

SMOOTH-SCALED GREEN SNAKE (*E. vernalis*). From Utah, New Mexico, and Texas northeastward to North Dakota and Illinois, thence eastward through New Jersey and through New England. It is either entirely absent from or exceedingly rare in the southeastern states.

31. RING-NECKED SNAKES (*Diadophis*).

KEY TO SPECIES

A1: Color of ventral plates of anterior part of body not reaching lowermost row of scales (Texas and eastern central United States eastward to Atlantic coast). EASTERN RING-NECKED SNAKE

A2: Color of ventral plates of anterior part of body covering one or more of lowermost rows of scales.

  B1: More than 206 and 220 ventral plates in males and females, respectively (central Texas westward into Arizona and southern Utah). SOUTHWESTERN RING-NECKED SNAKE

  B2: Fewer than 206 and 220 ventral plates in males and females (California and Oregon to extreme southern Washington). WESTERN RING-NECKED SNAKE

EASTERN RING-NECKED SNAKE (*D. punctatus*). This species is divided into four subspecies: one (*punctatus*) inhabiting the lower regions of the southeastern Atlantic and eastern Gulf states; another (*strictogenys*) found from southern Illinois southward throughout the lower Mississippi Valley; a third (*edwardsii*) occupying a triangular area from Wisconsin to Maine southward through the highest parts of the southeastern states; a fourth (*arnyi*) found westward from the ranges of the two preceding subspecies from extreme southwestern Wisconsin to South Dakota, Kansas, Oklahoma, and Texas.

SOUTHWESTERN RING-NECKED SNAKE (*D. regalis*). Two subspecies of this snake have been described: one (*regalis*) is found from central Texas westward to northern and eastern Arizona and southern Utah; the other (*arizonae*) in central and southern Arizona.

WESTERN RING-NECKED SNAKE (*D. amabilis*). Six subspecies of this snake have been discovered. They are widely distributed in California and range northward to extreme southern Washington.

32. YELLOW-LIPPED SNAKE (*Rhadinaea*).

YELLOW-LIPPED SNAKE (*R. flavilata*). Eastern North Carolina southward to Florida, thence westward to eastern Texas.

33. BLACK SWAMP SNAKE (*Seminatrix*).

BLACK SWAMP SNAKE (*S. pygaea*). Eastern North Carolina southward through Florida.

34. Sharp-tailed snake (*Contia*).

Sharp-tailed snake (*C. tenuis*). Pacific states but absent from extreme southern California.

35. Western ground snakes (*Sonora*).

Key to Species

- A1: Scales in 13 rows (southern Texas). Taylor's ground snake
- A2: Scales in 15 rows.
  - B1: Back with black cross-bands, the posterior ones continued on belly to encircle the body. Bicolored ground snake
  - B2: Black cross-bands, if present, never continued on belly to encircle the body. Hallowell's ground snake

Taylor's ground snake (*S. taylori*). Southern Texas.

Bicolored ground snake (*S. semiannulata*). Texas westward to southern California; northward to southern Kansas in the east and southern Idaho in the west. It is possible that two species are confused under this name, a great variation in coloration being exhibited by specimens to which the name *semiannulata* is frequently applied. The opinions of specialists differ.

Hallowell's ground snake (*S. occipitalis*). This snake lives in region of Mohave and Colorado Deserts.

36. Worm-snake (*Carphophis*).

Worm-snake (*C. amoena*). This species is divided into three subspecies: one (*amoena*) is found from Connecticut (formerly farther to the northeast) and southeastern New York southward to central Florida and westward into the Appalachian Mountains; a second (*helenae*) occurs from the range of the preceding subspecies westward to Illinois and Mississippi; a third (*vermis*) ranges from southeastern Nebraska, eastern Kansas, and central Missouri southeastward through Louisiana.

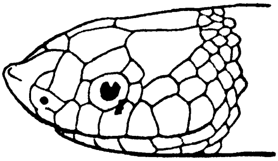
37. Banded burrowing snake (*Chilomeniscus*).

Banded burrowing snake (*C. cinctus*). Illus. facing page 105. This is a true desert snake. Southern Arizona and, rarely, extreme southeastern California.

38. Hook-nosed snakes (*Ficimia*).

Hook-nosed snake (*F. cana*). Fig. 23. The rostral completely separates the small internasals to make contact with the prefrontals. Western Texas to Arizona.

FIG. 23
Hook-nosed snake,
side and top of head.



STRECKER'S HOOK-NOSED SNAKE (*F. streckeri*). There are no internasals, the rostral separating the prefrontals to make broad contact with the frontal. Extreme southern Texas.

39. ARIZONA LONG-HEADED SNAKE (*Oxybelis*).

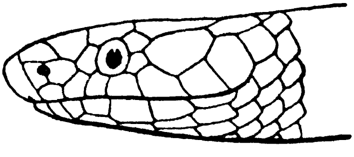
ARIZONA LONG-HEADED SNAKE (*O. microphthalmus*). Extreme southern Arizona.

40. BLACK-HEADED SNAKES (*Tantilla*).

KEY TO SPECIES

A1: A light cross-band on neck followed by a dark band.
  B1: Light cross-band on neck involving tips of parietals; 2 postoculars.
    C1: Dark cross-band on neck as wide as the length of 3 or 4 scales. CROWNED SNAKE
    C2: Dark cross-band on neck not as wide as the length of 2 scales (southeastern Arizona). ARIZONA BLACK-HEADED SNAKE
  B2: Light cross-band on neck separated from parietals by the length of 3 or 4 scales; usually a single postocular (southern California). CALIFORNIA BLACK-HEADED SNAKE
A2: No light cross-band on neck followed by a dark band.
  B1: Head brown, but little darker than body; 6 upper labials. SLENDER BLACK-HEADED SNAKE
  B2: Head black; 7 upper labials. BLACK-HEADED SNAKE

FIG. 24
Crowned snake,
side of head.



CROWNED SNAKE (*T. coronata*). Fig. 24. Southeastern United States northward to Tennessee and Virginia.

Arizona black-headed snake (*T. wilcoxi*). Southeastern Arizona.

California black-headed snake (*T. eiseni*). Southern California.

Slender black-headed snake (*T. gracilis*). Central Missouri and eastern Kansas southward through eastern Texas.

Black-headed snake (*T. nigriceps*). Central Texas westward into Arizona; northward into Kansas and southern Utah. This and the slender black-headed snake have recently been considered subspecies of a single species (*gracilis*).

41. Coral snake (*Micrurus*). Species of this genus are deadly poisonous.

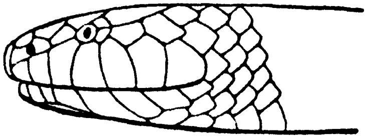


FIG. 25
Coral snake,
side of head.

Coral snake (*M. fulvius*). Fig. 25. This species is divided into two subspecies, one (*barbouri*) found only in extreme southern Florida, the other (*fulvius*) ranging from North Carolina southward through Florida, thence westward to extreme southeastern Oklahoma and through eastern and southeastern Texas; up the Mississippi and Ohio Valleys to southern Indiana.

42. Sonoran coral snake (*Micruroides*). Snakes of this genus are deadly poisonous.

Sonoran coral snake (*M. euryxanthus*). Illus. facing page 150. Southern Arizona.

43. Pygmy rattlesnakes (*Sistrurus*).

Massasauga (*S. catenatus*). Fig. 26. In this species there are 11 or more rows of scales at the middle of the tail and the upper preocular usually makes contact with the postnasal. Two subspecies of the massasauga are recognized: one (*catenatus*) occurs from extreme western Pennsylvania southwestward to extreme eastern Kansas and the northeastern tip of Oklahoma; northward to the southeastern corner of Nebraska, through southern and eastern Iowa, southern Wisconsin, Michigan (east of Lake Michigan), and northwestern New York; the other (*tergeminus*) is found from extreme southeastern Arizona northeastward to meet the eastern subspecies in eastern Kansas and northeastern Oklahoma; in Texas it occurs everywhere except in the southwestern extremity and the far eastern part.

GROUND RATTLESNAKE (*S. miliarius*). In this species there are 10 or fewer rows of scales at the middle of the tail and the upper preocular is not in contact with the postnasal. Three subspecies of this snake have been described: one (*barbouri*) found from the extreme southern tip of South Carolina southward through southern Georgia, all of Florida, extreme southern Alabama, and the southeastern extremity of Mississippi; another (*streckeri*) occurring from central Texas and southeastern Oklahoma eastward throughout Louisiana and Arkansas and into southwestern, extreme western, and northern Mississippi and southwestern Tennessee; also extreme southern Missouri; a third (*miliarius*) restricted to a narrow belt extending from southeastern North Carolina southwestward through South Carolina and central Georgia to central Alabama.

44. RATTLESNAKES (*Crotalus*). In order to simplify identification in a difficult group, I have based the key partly on geography to which special attention must be paid. Two generalizations about the rattlesnakes of *this genus* may prove helpful: In no part of the northern half of the United States does more than one species occur, and only the timber and eastern diamond-backed rattlers are found east of the Mississippi River. The section of the key dealing with the western species was kindly furnished by Mr. L. M. Klauber of California, who undoubtedly knows more about rattlesnakes than any other man alive.

KEY TO SPECIES

A1: Species found east of a line extending through central Texas northward to central Kansas, thence northeastward to the northwestern boundary of Wisconsin.

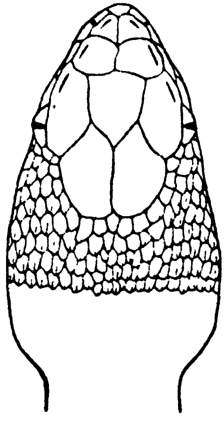


FIG. 26
Massasauga,
top of head.

B1: Back with numerous dark cross-bands irregular in outline and sometimes broken up into series of spots, or somewhat connected anteriorly to form a pair of longitudinal stripes (widely distributed in eastern United States). TIMBER RATTLESNAKE

B2: Back with a series of symmetrical light-edged diamond-shaped blotches (illustration facing page 95).

C1: Found in the southeastern coastal strip from eastern North Carolina throughout Florida to extreme eastern Louisiana. DIAMOND-BACKED RATTLESNAKE

C2: Found (in area covered by this section of key) only from central Texas to but not including extreme eastern Texas and from central through southeastern Oklahoma and a narrow strip of Arkansas to extreme southeastern Missouri. WESTERN DIAMOND-BACKED RATTLESNAKE

B3: Back with a series of even-edged subrectangular blotches. This snake barely enters the area of this section of the key from central Kansas southward through central Texas. It is not found in extreme eastern Texas, central or eastern Oklahoma, or extreme eastern Kansas. PRAIRIE RATTLESNAKE

A2: Species found west of the line indicated above.

B1: Outer edge of scale above eye, the supraocular, raised into a flexible horn-like process. SIDEWINDER

B2: No horn-like process above eye.

C1: Tip of snout raised into a sharp ridge; a vertical light bar across end of snout to tip of lower jaw (extreme southeastern Arizona). WILLARD'S RATTLESNAKE

C2: Tip of snout not raised into a sharp ridge; no vertical light stripe on end of snout and tip of lower jaw.

D1: Back with 2 parallel rows of small brown blotches on a steel-gray ground color (southeastern Arizona). PRICE'S RATTLESNAKE

D2: Back without 2 parallel rows of small brown blotches on a steel-gray ground color.

E1: Rostral separated by small scales or granules from the prenasal, or scale bordering front of nostril (central and southwestern Arizona and extreme southern California). SPECKLED RATTLESNAKE (southern subspecies)

E2: Rostral in contact with scale bordering front of nostril (Fig. 28).

F1: Upper preocular divided vertically, the anterior section being higher than the posterior and curved over head in front of scale above eye; cross-bands of back separated by interspaces wider than the bands themselves (southwestern Texas into southwestern New Mexico and southeastern Arizona). ROCK RATTLESNAKE

F2: Upper preocular not divided (Fig. 28); back without cross-bands separated by wider interspaces.

- G1: Tail entirely black or black with faint grayish cross-bands (southwestern Texas westward through southwestern New Mexico and through southeastern to central Arizona). BLACK-TAILED RATTLESNAKE
- G2: Tail not entirely black, or black with faint grayish cross-bands.
  - H1: More than 2 internasals or scales making contact with rostral and lying between nasals (Fig. 27). PRAIRIE, GREAT BASIN, and PACIFIC RATTLESNAKES
  - H2: Only 2 scales making contact with rostral and lying between nasals.
    - I1: Scale above eye either pitted, sutured, or with broken outer edge (southwestern Nevada and adjacent southern California). SPECKLED RATTLESNAKE (northern subspecies)
    - I2: Scale above eye neither pitted, sutured, nor with broken outer edge.
      - J1: Head small, its length in adults contained more than 25 times in body length (south-central Arizona). TIGER RATTLESNAKE
      - J2: Head length contained less than 25 times in body length.
        - K1: Anterior part of scale above eye separated from its fellow of opposite side usually by only 2 scales; a light stripe passing backward from eye above mouth. MOHAVE RATTLESNAKE
        - K2: Anterior part of scale above eye separated from its fellow by more than 2 scales; light line from behind eye, if present, crosses mouth.
          - L1: Ground color of pink, brick-red, or reddish brown not heavily dotted with small dark spots (extreme southwestern California). RED DIAMOND-BACKED RATTLESNAKE

L2: Ground color of cream, buff, gray, or gray-brown heavily dotted with small dark spots.
Western diamond-backed rattlesnake

Timber rattlesnake (*C. horridus*). Two subspecies of this snake are recognized. One (*atricaudatus*) is found from central and southeastern Texas eastward throughout the coastal plain of the southeastern states except peninsular Florida, and up the Mississippi Valley to southern Illinois. The other (*horridus*) occurs northward from the range of the southern subspecies through the Atlantic states, Ohio, Illinois, Indiana, extreme southeastern Minnesota, and the southeastern tip of Nebraska.

Diamond-backed rattlesnake (*C. adamanteus*). Illus. facing page 95. Southeastern coastal strip from eastern North Carolina throughout Florida to extreme eastern Louisiana.

Western diamond-backed rattlesnake (*C. cinereous,* formerly known as *C. atrox*). Illus. facing page 25. From extreme southeastern California eastward through most of Arizona and New Mexico, all of Texas but its extreme eastern and northern parts, central and southeastern Oklahoma, and through a narrow strip of Arkansas to extreme southeastern Missouri.

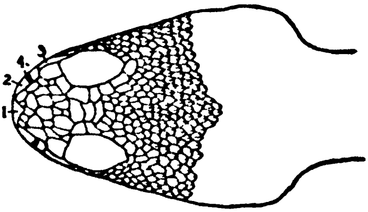


FIG. 27

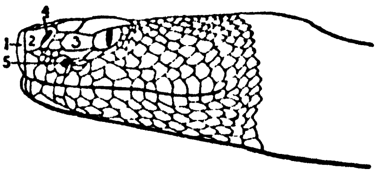


FIG. 28

Prairie rattlesnake, top and side of head with important scales and parts numbered: (1) the rostral, (2) the prenasal, (3) the upper preocular, (4) the nostril, and (5) the pit.

Prairie, Great Basin, and Pacific rattlesnakes (*C. viridis,* formerly known as *C. confluentus*). Figs. 27 and 28. This species is divided into six subspecies some of them differing widely in general appearance. They are distributed as follows:

The prairie rattlesnake (*viridis*) found from central Texas northward into southwestern North Dakota; westward throughout New Mexico into northeastern Arizona and southeastern Utah and through most of Colorado, Wyoming, and Montana.

The pacific rattlesnake (*oreganus*) distributed over all of California except its southeastern and extreme eastern sections, southwestern through northeastern Oregon, and eastern and central Washington.

The great basin rattlesnake (*lutosus*) occupying most of the region between the ranges of the two preceding subspecies from southeastern Oregon and southern Idaho southward through western Utah, extreme northwestern Arizona, most of Nevada, and a strip of extreme eastern California.

A fourth (*abyssus*) confined to the Grand Canyon of the Colorado River, northern Arizona.

A fifth (*nuntius*) found only in a section of northern Arizona lying east and just south of the Grand Canyon.

A sixth (*concolor*) occurring in eastern Utah, extreme western Colorado, and extreme southwestern Wyoming.

Sidewinder (*C. cerastes*). Illus. following p. 76. This snake is found only in deserts. Extreme southwestern Utah and southern Nevada southward through western Arizona and southeastern California.

Willard's rattlesnake (*C. willardi*). Extreme southeastern Arizona.

Price's rattlesnake (*C. triseriatus*). Southeastern Arizona.

Speckled rattlesnake (*C. mitchellii*). Two subspecies of this snake are recognized, a southern one (*pyrrhus*) found in central and southwestern Arizona and extreme southern California, and a northern one (*stephensi*) confined to southwestern Nevada and adjacent southern California.

Rock rattlesnake (*C. lepidus*). Two subspecies of this snake have recently been diagnosed, one (*lepidus*) occurring in southwestern Texas to but not including the El Paso region, the other (*klauberi*) found from the El Paso region of extreme western Texas into southwestern New Mexico and southeastern Arizona.

Black-tailed rattlesnake (*C. molossus*). Southwestern Texas westward through southwestern New Mexico and southeastern to central Arizona.

Tiger rattlesnake (*C. tigris*). South-central Arizona.

Mohave rattlesnake (*C. scutulatus*). Extreme southwestern New Mexico northwestward through southern and central Arizona to southern Nevada, thence westward into southern California.

Red diamond-backed rattlesnake (*C. ruber*). Extreme southwestern California.

45. Copperhead and water moccasin (*Agkistrodon*).

Copperhead (*A. mokasen*). Illus. facing page 76. This snake is not semiaquatic. It has a loreal separating the preocular from the posterior nasal;

the eye is separated from the upper labials by small scales; and the scales are normally in 23 rows at midbody. The pattern of reddish brown cross-bands on a grayish or pinkish brown ground color remains vivid throughout life. Two subspecies are recognized: one (*mokasen*) found southward from New York and Massachusetts to northern Florida; westward to Illinois, central Kansas, eastern Oklahoma, and central Texas; the other (*laticinctus*) occurs from western and central Texas northeastward to central Oklahoma. This western subspecies is distinguished from the eastern one chiefly by wider cross-bands.

WATER MOCCASIN (*A. piscivorus*). This is a semi-aquatic species. The absence of a loreal allows the preocular to make contact with the posterior nasal; the upper labials reach the eye and the scales are in 25 rows at midbody. The pattern of wide dark cross-bands on a brown or olive ground color becomes obscure in adults. Southeastern Virginia southward through Florida, thence westward to central Texas; northward in the Mississippi Valley to southern Illinois.

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